The Federal Aviation Administration

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HUMAN FACTORS ACQUISITION JOB AID

Federal Aviation Administration
Human Factors Research and Engineering Division

Preface Human Factors Acquisition Job Aid

JOB AID PURPOSE

The purpose of this Human Factors Job Aid is to serve as a desk reference for human factors integration during the lifecycle acquisition management process. The first chapter contains an overview of the FAA human factors process. The remaining chapters each represent a function that must be accomplished to produce a successful human factors program. The chapters offer one way that has proven successful during previously conducted acquisition programs to accomplish the integration of human factors. The "How To" section of each chapter provides the steps to complete the function. Checklists are included to assist in the execution and implementation of a human factors program. References are provided in Appendix D.

The processes described in this Job Aid apply to all types of acquisition programs (systems, software, facilities, and services). As used in this Job Aid, the term "acquisition" refers to all four program types in the lifecycle acquisition management process. The emphasis of this Job Aid is primarily on systems and software because these acquisitions often afford the greatest opportunities for human factors influences; the activities and terminology

may need to be tailored for facility and services acquisitions.

HUMAN FACTORS IN FAA ACQUISITIONS

Appendix F contains a flowchart depicting Human Factors in the FAA Acquisition Management System process. This provides an overarching structure for the human factors activities in an acquisition program.

The **left axis** of the flow chart outlines four management "vectors" of the human factors program:

- **Manage the human factors program**
- **Establish human factors requirements**
- **Conduct human factors system integration**
- **Conduct human factors test and evaluation.**

The **top axis** shows each phase of the Acquisition Management System lifecycle. The chart shows what tasks need to be accomplished, when they are conducted within the acquisition process, which chapter provides information on how to perform the tasks, and how the tasks fit into four management "vectors" to assist in managing the process.

The critical impact of human factors on acquisitions is well-documented in programs, studies, and analyses. The FAA Acquisition Management System policy states: "Integrated Product Teams must assure that planning, analysis, development, implementation, and in-service activities for equipment, software, facilities, and services

include human factors engineering to ensure performance requirements and objectives are consistent with human capabilities and limitations. Human factors engineering should be integrated with the systems engineering and development effort throughout the acquisition process, starting with mission analysis and continuing through solution implementation and in-service management." The Job Aid will help in this endeavor.

JOB AID AVAILABILITY AND UPDATES

This Job Aid and updates to it are available on the FAA Human Factors home page at http://www.hf.faa.gov. Additional information on human factors support and requirements can be obtained from the Human Factors Research and Engineering Division, AAR-100, (202) 267-7219.

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Chapter 1 FAA Human Factors Overview

PURPOSE

This chapter defines human factors in the context of the total system concept in which the operator, maintainer, and operating environment are integral components of the system. When human factors is applied early in the lifecycle acquisition management process, it enhances the probability of increased performance, safety, and productivity; decreased lifecycle staffing and training costs; and becomes well-integrated into the program's strategy, planning, cost and schedule baselines, and technical trade-offs.

Changes in operational, maintenance or design concepts during the later phases of an acquisition are expensive and entail high risk program adjustments. Identifying lifecycle costs and human performance components of system operation and maintenance during investment analysis and requirements definition decreases program risks and long-term operations costs. These benefits are applicable to commercial-off-the-shelf (COTS) and non-developmental items (NDI) as well as to developmental programs.

TIMING

Efforts to manage the human factors program, establish requirements, conduct system integration, and test and evaluate human factors compliance must be integral with the acquisition process. This integration is shown in the Human Factors in the FAA Acquisition Management System process flowchart in Appendix F.

DEFINITION OF HUMAN FACTORS

Human factors is a multidisciplinary effort to generate and compile information about human capabilities and limitations and apply that information to:

- Equipment
- Systems
- Software
- Facilities
- Procedures
- Jobs
- Environments
- Training
- Staffing
- Personnel management

to produce safe, comfortable, effective human performance (Figure 1-1).

Thus there are two components to human factors: a) human factors research (acquiring the information), and b) human factors engineering (applying the information).

There are many terms that are commonly used to reflect the considerations of human factors, including Man-Machine Integration (MMI), Human-System Integration (HSI), Computer-Human Interface (CHI), Human Engineering,

Ergonomics, and others. Although the use of these terms often encompasses a scope similar to "human factors," there is an unadvised tendency for them to assume a more limited definition. From the perspective of human factors professionals, use of these terms should intend to span the comprehensive breadth of the human factors definition that emphasizes total human-system performance.

THE TOTAL SYSTEM CONCEPT

Experience has proven that when people think of acquiring a system, they tend to focus on the hardware and the software that is being purchased. Individuals often fail to visualize that the hardware/software will be operated and maintained by people. These people will have different aptitudes, abilities, and training and will operate the system under various operating conditions, organizational structures, procedures, equipment configurations, and work scenarios. The total composite of these elements and the human component will determine the performance, safety, and efficiency of the system in the National Airspace System (NAS).

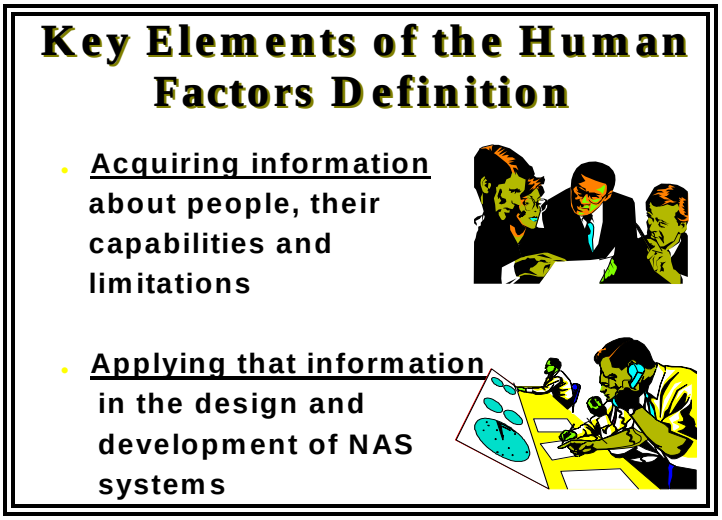

Figure 1-1. Definition of human factors.

To produce an effective human factors program for any acquisition, the definition of the system should include not only the *hardware, software, facility, and services*, but also the *users* (*operators and maintainers)* and the *environment* in which the acquisition is employed (Figure 1-2).

[For the purpose of this document, the term *user* refers to the personnel that operate equipment to perform NAS tasks and operations (operators) as well as those expected to support the system throughout its lifecycle (maintainers). The term *customer* refers to NAS customers.]

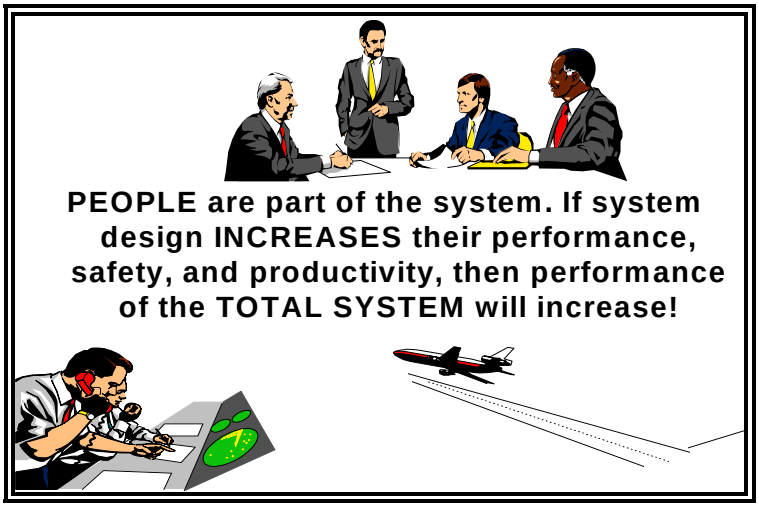

Figure 1-2. Users as part of the system.

TOTAL SYSTEM PERFORMANCE

A Total System Performance equation is presented in Figure 1-3. The probability that the total system will perform correctly, when it is available, is the probability that the hardware/ software will perform correctly, times the probability that the operating environment will not degrade the system operation, times the probability that the user will perform correctly.

By defining total system this way, human performance is calculated as a component of the hardware and software system. A system can operate perfectly from an engineering sense in a laboratory or at a demonstration site and then not perform well when it is operated by the operators and maintainers at a field location.

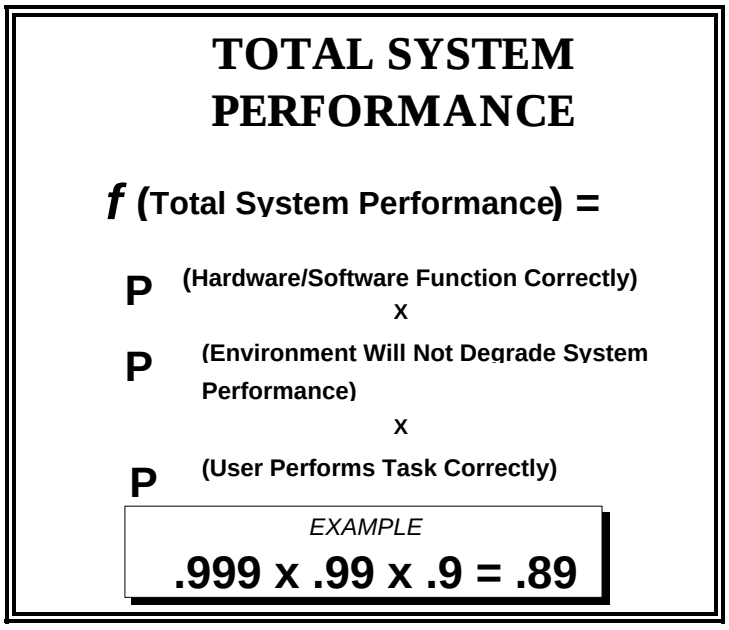

Figure 1-3. Calculation of total system performance.

By increasing the probability that the operator can perform the task effectively in the appropriate environment the Total System Performance will increase significantly.

APPLICATION OF HUMAN FACTORS INCREASES PERFORMANCE, LOWERS COST

Four variables commonly having a significant impact on total system performance (Figure 1-4) are:

- Equipment/Software design
- Environment
- Staffing and Training
- Procedures**.**

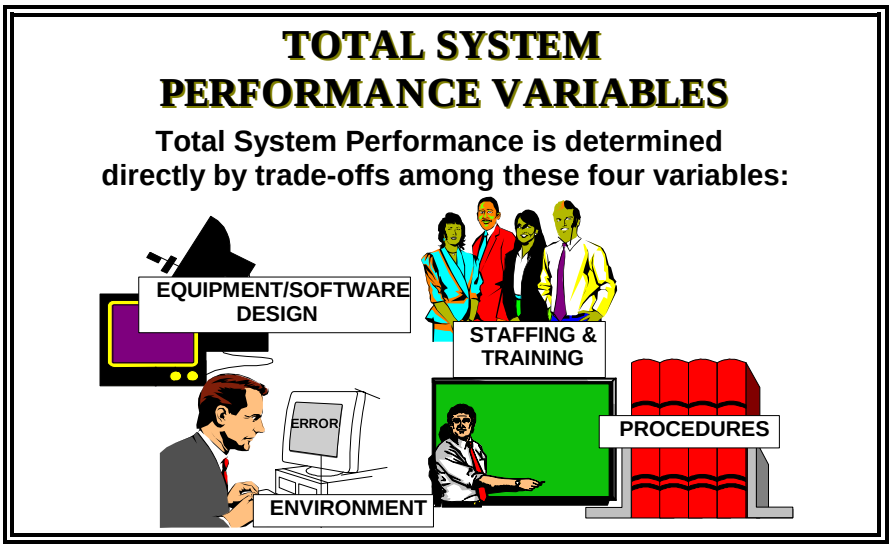

Figure 1-4. Variables in total system performance.

Since these dynamic variables interact with each other, trade-off decisions are required to optimize operational system performance.

Hardware and software design affects both the accuracy of operator task performance and the amount of time required for each task. Applying human factors principles to system design will increase performance accuracy and will decrease performance time. Research has shown that designing the system to improve human performance is the most cost-effective solution… especially if it is done early in the acquisition process.

EARLY APPLICATION OF HUMAN FACTORS

In the early phases of system design or development, functions are allocated to hardware, software, or people (or they can be shared). For system and software acquisitions (especially NDI/COTS), a market survey is conducted to reveal what and how candidate systems and software have already made these functional allocations in ways that do or do not enhance total system performance. Identifying human-system performance sensitivities associated with competing vendors/designs lowers technical risks and lifecycle costs (research, engineering, and development; acquisition; and operations over the economic life of the system). Since operations costs are often much greater than the costs for research, engineering, development and acquisition, early assessment of lifecycle costs has significant benefit to the total program cost.

Early decisions made with little regard to operator capabilities and limitations are likely to result in expensive training, staffing, or re-design solutions (Figure 1-5).

By focusing on the total system, the performance of the user is enhanced, thereby increasing the performance of the system (in its operational setting, using typical operators and maintainers). If, in the previous example, the probability that the user correctly performs the task increases from .9 to .99, total system performance will increase from .89 to .98 (Figure 1-6).

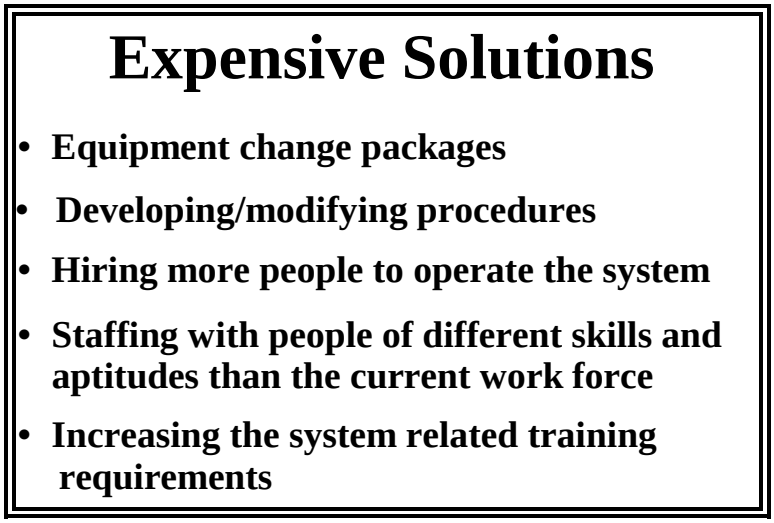

Figure 1-5. High cost solutions.

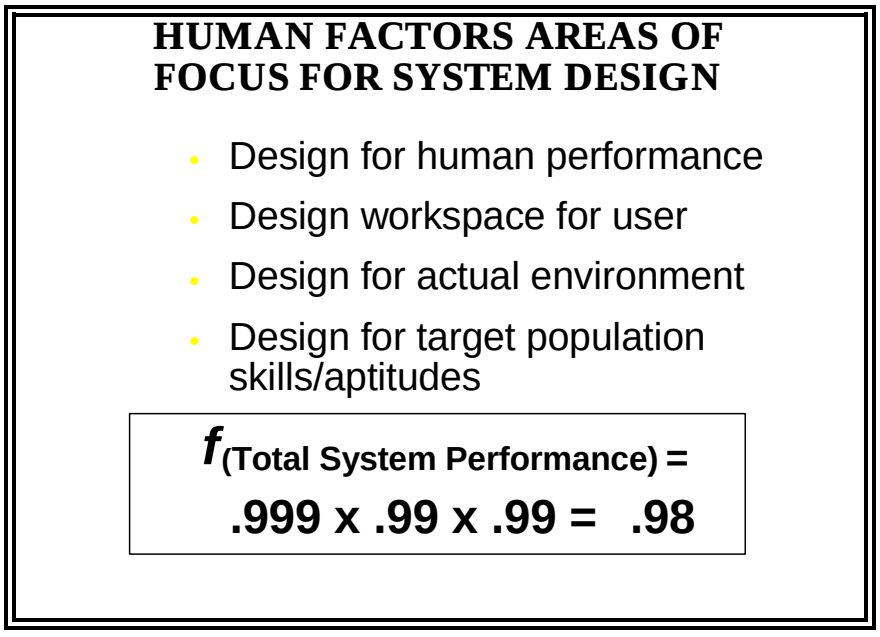

Figure 1-6. Focusing on the user enhances total system performance.

The early development and application of a human factors program is an important key to system cost and risk reduction (Figure 1-7). Most lifecycle costs are determined by decisions made during the Investment Analysis and Solution Implementation phases of the acquisition process.

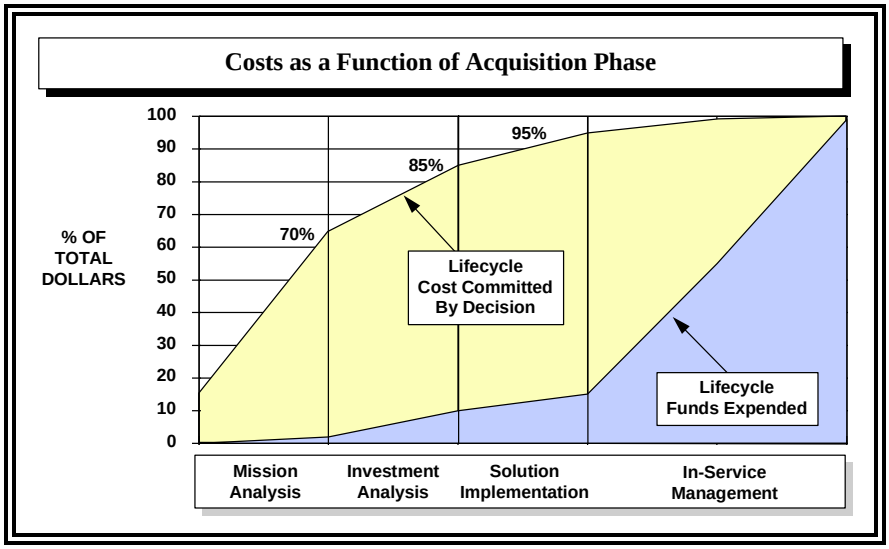

Figure 1-7. Timing of lifecycle costs.

Human factors issues need to be identified and addressed early in the acquisition process. Doing so helps detect and resolve potential performance problems at the lowest cost (Figure 1-8).

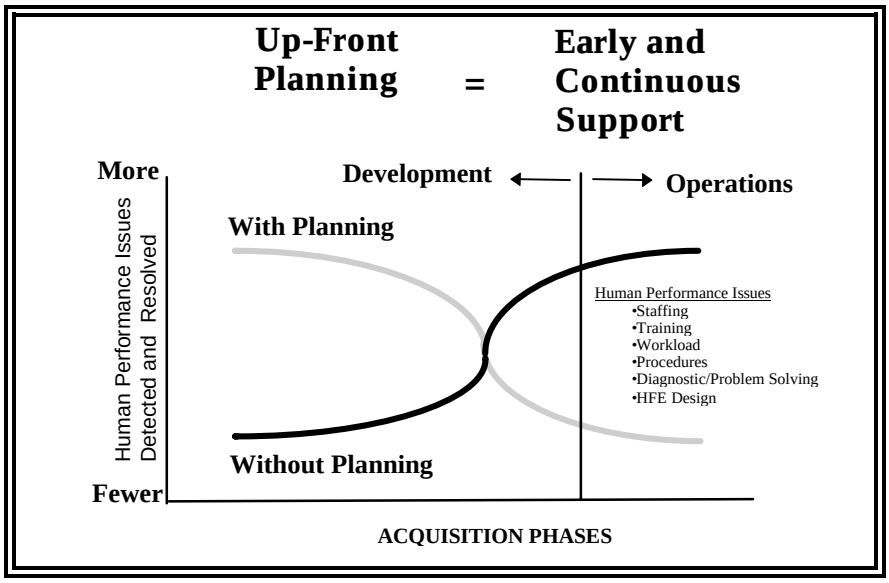

Figure 1-8. Benefits from up-front planning.

"HOW TO"

Human factors is a multidisciplinary effort to generate, compile, and apply information about human capabilities and limitations.

Human factors professionals can assist in applying human factors information related to human resources management, training, safety, medical, and human engineering.

The human factors process consists of four management actions:

- Manage the human factors program
- Establish human factors requirements
- Conduct human factors system integration
- Conduct human factors test and evaluation.

The human factors functions are integrated within the acquisition process as shown in the following table. An enlarged version of this table is shown in Appendix F (Human Factors in the FAA Acquisition Management System process flowchart). Each function is addressed in the chapters identified in the Job Aid.

HUMAN FACTORS IN THE FAA ACQUISITION MANAGEMENT SYSTEM PROCESS

(COTS, NDI & Developmental Systems, Services, and Facilities)

PHASE / ACTION	MISSION ANALYSIS	INVESTMENT ANALYSIS	SOLUTION IMPLEMENTATION	IN-SERVICE MANAGEMENT (INCLUDING SERVICE LIFE EXTENSION)
MANAGE THE HUMAN FACTORS PROGRAM	• Identify Human Performance Deficiencies (Ch. 2) • Identify Opportunities to Improve Human Performance (Ch. 2) • Initiate Human Factors Goals and Objectives (Ch. 2)	• Designate Human Factors Coordinator (Ch. 3) • Establish Human Factors Working Group (Ch. 3) • Develop the Human Factors Program (Ch. 3) • Draft Input to the IPP (Ch. 2 and 3)	• Refine the Human Factors Program (Ch. 3) • Prepare Human Factors Input to the IPP (Ch. 2 and 3)	• Refine the Human Factors Program (Ch. 3) • Revise the Human Factors Portion of IPP (Ch. 2 and 3)
ESTABLISH HUMAN FACTORS REQUIREMENTS	• Identify Human Factors Shortfalls and Human Resource Constraints (Ch. 2 and 4)	• Conduct Human Factors Assessment and Establish Human Factors Requirements in Acquisition Documents (Ch. 2, 4, and 5) • Formulate Draft Human Factors Requirements for a System Specification (Ch. 6) • Generate Initial Human Factors Input to the SOW (Ch. 7)	• Revise Human Factors Requirements in the System Specification (Ch. 6) • Refine Human Factors Input to the SOW (Ch. 7) • Specify Human Factors Requirements for Source Selection (Ch. 8)	• Update Human Factors Requirements for System Modifications and Upgrades (Ch. 2, 4, 6, and 7)
CONDUCT HUMAN FACTORS SYSTEM INTEGRATION	• Identify Potential Human Factors Analyses and Trade-offs (Ch. 9)	• Provide Human Factors Inputs to Acquisition Documents (Ch. 2) • Initiate Human Factors Tasks and Activities (Ch. 5 and 9) • Coordinate Human Factors Tasks and Activities with ILS (Ch. 11)	• Revise Human Factors Inputs to Acquisition Documents (Ch. 2) • Continue Human Factors Tasks and Activities (Ch. 9) • Coordinate Results of Human Factors and ILS Analyses (Ch.11)	• Monitor Results of Human Factors and ILS Activities (Ch. 9 and 11)
CONDUCT HUMAN FACTORS TEST AND EVALUATION	• Conduct Preliminary Concept Assessments, Validations, or Demonstrations (Ch. 4 and 10)	• Draft Human Factors Inputs for T&E Plans (Ch. 10) • Conduct Front-end Studies and Analysis (Ch. 4, 5, and 10)	• Revise Human Factors Inputs to T&E Plans (Ch. 10) • Participate in Developmental and Operational Testing (Ch. 10)	• Monitor Human Factors Test and Evaluation Activities (Ch. 10) • Conduct Post-Deployment Assessments (Ch. 10)

Chapter 2 Develop Human Factors Inputs for Acquisition Documentation

PURPOSE

The purpose of this function is to present the human factors inputs for integration in system acquisition documentation. Although human factors inputs are developed and iterated throughout the entire acquisition cycle, primary inputs are often through acquisition documentation. This chapter shows how the Human Factors Coordinator, working with the other Integrated Product Team (IPT) and human factors user group members, develops human factors inputs to these acquisition documents. (As used in this document, IPT refers to the IPT and/or the Product Team.)

The acquisition documents are identified, and typical inputs are discussed which help ensure that human performance supports system performance goals and objectives.

ACQUISITION DOCUMENTS

The key documents in a system acquisition requiring an input relative to human factors are the:

- Mission Need Statement (MNS). The MNS defines a mission capability shortfall or technological opportunity the FAA should address and includes consideration of major human resource and human-system performance issues.
- Requirements Document (RD). The RD establishes the performance baseline and operational framework for an acquisition program and includes human-system interfaces and human performance requirements.
- Investment Analysis Report (IAR). The IAR summarizes the analytical and quantitative information developed during investment analysis in the search for the best means for satisfying a mission need and identifies the human resource and performance trade-offs in terms of cost and benefit.
- Acquisition Program Baseline (APB). The APB establishes the performance, cost, schedule, and benefits baseline within which an acquisition must be implemented and includes human-system performance thresholds and concepts for conducting the supporting Human Factors Program.
- Acquisition Strategy Paper (ASP). The ASP defines the overall strategy by which an

acquisition program will be implemented and outlines the strategy and objectives for the supporting Human Factors Program.

- Integrated Program Plan (IPP). The IPP describes the detailed planning for all aspects of the program implementation and specifies the Human Factors Program tasks, activities, controls, responsibilities, and schedule.

TIMING

- The MNS is prepared in the Mission Analysis phase. Joint Resources Council (JRC) approval of the MNS initiates entry into the Investment Analysis phase. The MNS is revalidated at the Investment Decision. Incorporation of major human resource and performance considerations provides a basis for addressing constraints related to the human component of the required capability.
- The RD is initiated in the Mission Analysis phase or prepared early in the Investment Analysis phase, and is approved and baselined at the Investment Decision. It is at this point that detailed consideration of human-system interfaces and human performance requirements, characteristics, and criteria are initiated.
- The IAR is prepared during the Investment Analysis phase as the primary decision document at the Investment Decision. Identifying the human resource and

performance trade-offs at this point provides insight into their impact on the operational suitability and operational effectiveness in quantifiable cost and benefit terms.

- The APB is baselined at the Investment Decision. Identifying the human-system performance thresholds and concepts for conducting the supporting human factors program in the APB establishes a reference point for all future human factors trade-offs in operational suitability and operational effectiveness.
- The ASP is prepared early in the Solution Implementation phase. Providing a human factors strategy in the ASP helps ensure that the solicitation addresses critical human factors contractor services.
- The IPP is initiated during the Investment Analysis phase and prepared early in the Solution Implementation phase. The human factors portion of the IPP (the Integrated Human Factors Plan, or IHFP) provides an early and clear definition of the work to be conducted under the human factors program.

"HOW TO"

There is a strong link between the acquisition documentation and the planning, management, and execution of the system acquisition program. The acquisition documentation defines the performance requirements and capabilities the

system is to meet, the approach to be taken, and the specific tasks and activities that must be performed during system design, development, and implementation.

Similarly, the human factors inputs to the acquisition documentation accomplish the same result regarding the Human Factors Program. Human factors inputs define human performance requirements and criteria, identify human performance and resource trade-offs, specify human performance thresholds, establish an approach to ensure human performance supports system performance, and define the specific tasks and activities to be conducted.

Without such input, the capabilities and limitations of the designated operators and maintainers will not adequately influence the design, and may result in lower levels of operational suitability and effectiveness.

Mission Need Statement

Using the results from the mission analysis, human factors inputs to the MNS identify the human performance constraints and issues that need to be addressed or resolved. This information may come from operations and maintenance concepts, similar systems or components, and other documents that may provide insights into the effects of human factors constraints and limitations on system performance.

Since most acquisitions are evolutionary, important human factors information can be obtained from

predecessor systems or their component subsystems.

Analyses and trade-off studies may be required to determine the effects of constraints and issues on system performance. The existing literature and lessons learned data bases should be reviewed.

Requirements Document

The initial RD contains generic performance and supportability requirements that do not prescribe a specific solution. The RD defines the essential performance capabilities and characteristics, including those of the human component.

Human factors inputs to the RD identify requirements for human performance factors that impact system design. Broad cognitive, physical, and sensory requirements for the operator, maintainer, and support personnel that contribute to or constrain total system performance are established.

Any safety, health hazards, or critical errors that reduce job performance or system effectiveness should be defined. The staffing and training concepts to include requirements for training devices, embedded training, and training logistics should also be described.

Investment Analysis Report

Human factors inputs to the IAR address, for each alternative being evaluated, the full range of human performance and interfaces (e.g., cognitive,

organizational, physical, functional, and environmental) necessary to achieve an acceptable level of performance for operating, maintaining, and supporting the system.

The analysis should provide information on what is known and unknown about human performance risks in meeting minimum system performance requirements.

Human factors areas of interest relevant to the investment analysis include:

- Human performance (e.g., human capabilities and limitations, workload, function allocation, hardware and software design, decision aids, environmental constraints, team versus individual performance).
- Training (e.g., length of training, training effectiveness, retraining, training devices and facilities, embedded training).
- Staffing (e.g., staffing levels, team composition, organizational structure).
- Personnel selection (e.g., aptitudes, minimum skill levels, special skills, experience levels).
- Safety and health hazards (e.g., hazardous materials or conditions, system or equipment safety design, operational or procedural constraints, biomedical influences, protective equipment, required warnings and alarms).

Acquisition Program Baseline

The APB is established at the Investment Decision and reflects the solution selected by the JRC for implementation. Based on the solution selected, human factors inputs to the APB are those human performance requirements necessary to achieve the required level of system performance. These inputs are derived from those identified in the Requirements Document and reflect a refinement that provides increased definition, greater granularity, and more specificity of relevant human-system performance characteristics. Constraints, limitations, and unique or specialized training requirements, staffing levels, or personnel skill requirements should be identified.

To the degree possible, the required level of human performance should be based upon practical measures of operational effectiveness and suitability and should be stated in quantifiable terms (e.g., time to complete a given task, level of accuracy required, number of tracks to be processed per unit time).

Acquisition Strategy Paper

The ASP presents the Integrated Product Team's strategy for the technical, management, and procurement approach that will be used to execute the program. Each of the individual strategies, to include human factors, is planned in greater detail in the IPP.

Human factors input to the ASP is the strategy to be employed to ensure that the system being acquired is well designed and appropriate for the workforce that will operate and maintain it. This strategy should be consistent with the nature, size, and complexity of the system.

The strategy should define how the level of human performance necessary to meet the required system performance will be assured. Additionally, the strategy should describe how the system design would be influenced by the capabilities and limitations of the operators, maintainers, and support personnel.

Integrated Program Plan

Building upon the content of the ASP, human factors inputs to the IPP should be a detailed listing of the specific human factors tasks and activities that must be planned and executed to support the acquisition system design and development. This listing should include those tasks and activities to be performed by the government as well as by the contractor. The portion of the IPP may be documented as an Integrated Human Factors Plan (IHFP). The human factors tasks and activities should be consistent with the nature, size, and complexity of the system being acquired.

The tasks and activities should ensure that the system design:

- Is influenced by the capabilities and limitations of the designated operators, maintainers, and support personnel.
- Provides the required level of human performance necessary to support the overall system performance objectives and requirements.
- Addresses human resource constraints as well as unique or specialized training requirements, staffing levels, or personnel skills.

The scheduling of the human factors tasks and activities should be integrated with system engineering, test and evaluation, and key program milestones to ensure that the output products are available in a timely manner to support and influence the system design and development.

CHECKLIST QUESTIONS

- Was the human element fully addressed in the mission analysis?
- Does the Mission Need Statement input describe the human performance limitations associated with the capability shortfall or human performance enhancements associated with the new technology opportunity?
- Is the human considered part of the total system in addressing the capability shortfalls or technological opportunities in the Mission Need Statement?

- Does the Requirements Document input ensure that the human is considered as part of the total system when addressing the required capabilities and system performance?

- Do operations and maintenance concepts in the Requirements Document adequately describe the role of the operators, maintainers, and support personnel?

- Does the Investment Analysis Report input address the human factors lifecycle cost and benefits in terms of staffing, training, skills, safety, health, and human-system performance and interfaces for each alternative being considered?

- Does the Investment Analysis Report baseline cost and schedule include considerations for suitable human factors design trade-offs, test and evaluation, and in-service operations and maintenance.

- Does the Acquisition Program Baseline input identify the level of human performance and resources (e.g., personnel, training) necessary to meet the system performance requirements for the selected solution?

- Does the Acquisition Program Baseline include human factors components, as appropriate, in the performance, cost, schedule, and benefits baseline?

- Does the Acquisition Strategy Paper input describe a human factors strategy to be

employed to ensure the system is well-designed and appropriate for the workforce that will operate and maintain it?

- Does the Integrated Program Plan input identify the specific human factors tasks and activities that must be planned and executed to support the system design and development?
- Are the human factors tasks and activities scheduled such that output products will be available in a timely manner?
- Are the human factors inputs consistent with the nature, size, and complexity of the system being acquired?
- Have constraints, limitations, and unique or specialized training requirements, staffing levels, or personnel skill requirements been addressed?

Chapter 3 Develop the Human Factors Program

PURPOSE

This chapter defines the overarching strategy for the conduct of a human factors effort in support of system acquisition programs. The Human Factors Program establishes the approach for applying human factors engineering to the individual systems being acquired through the Integrated Human Factors Plan. The goal is to increase total system performance and reduce developmental and lifecycle costs by optimizing human performance when the system is operated and maintained in the operational environment by members of the target population.

TIMING

The Human Factors Program and its Integrated Human Factors Plan (IHFP) should be initiated early in the Investment Analysis phase of the system acquisition process and refined during each subsequent acquisition phase, as required.

"HOW TO"

Establishing a Human Factors Program for a given system acquisition requires focusing on the tasks the humans (operators, maintainers, and support personnel) will perform on the system, and the program activities that must be undertaken during the acquisition to allow early identification and

resolution of human performance issues. Figure 3-1 illustrates the steps to be taken in developing the Human Factors Program.

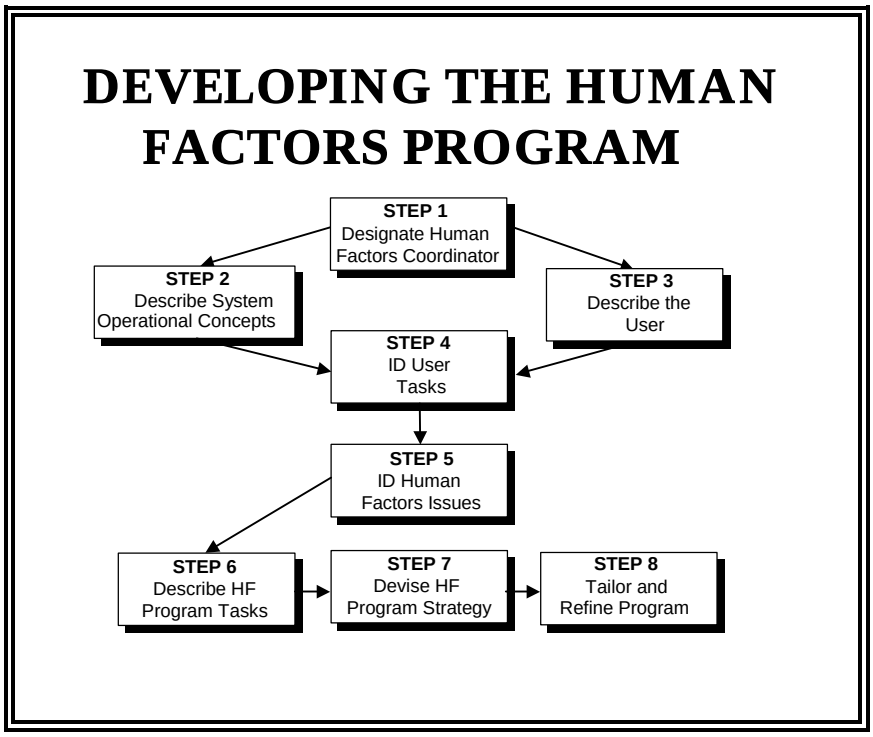

Figure 3-1. Steps in developing a Human Factors Program.

Step 1: Designate a Human Factors Coordinator

The Integrated Product Team (IPT) Lead will designate a Human Factors Coordinator (HFC) to coordinate the Human Factors Program and the development of the Integrated Human Factors Plan for a particular system. The Human Factors Coordinator will develop, direct, and monitor the Human Factors Program and its activities for the system acquisition.

The Human Factors Coordinator role in IPT activities is to perform, direct, or assist in:

- Defining human factors impacts and constraints during investment analysis and requirements determination
- Development of the Integrated Human Factors Plan for the system
- Support to the Product Team Lead in the identification and mitigation of Human Factors risks
- Support to the Product Team Lead in the achievement of the human factors aspects of program technical cost and schedule goals
- Specifying the organizational resources that will have a role in the execution of portions of the Integrated Human Factors Plan including vendor organizations, IPT support personnel, Technical Center test and human factors personnel or other sources
- Identifying human-system interfaces for market surveys, trade-off analyses, and prototypes
- Preparing and updating human factors portions of acquisition documents, procurement packages, performance measures and criteria, and data collection efforts
- Developing and analyzing operational scenarios and human-system modeling (with human-in-the-loop) for operators and maintainers

- Reviewing and assessing human factors concepts and designs
- Coordinating human factors efforts and working group activities with the FAA Human Factors Research and Engineering Division.
- Coordinating human factors with system engineering and other disciplines including, where relevant, the Air Traffic System representatives, user groups, and unions
- Oversee the development of HF requirements and contractual documentation including the vendor's Human Engineering Program Plan (see Chapter 7)
- Monitoring performance of the vendor's Human Engineering Program Plan

To facilitate accomplishment of human factors tasks and activities, the HFC may establish and chair a Human Factors Working Group (HFWG). Initial HFC duties may involve submitting a recommended HFWG membership list and operating procedures for approval.

(*Note: A sample set of HFWG operating procedures is included at the end of this chapter*).

The HFC will ensure that human factors issues are identified and addressed for the system acquisition and that the human factors strategy is formulated and applied.

The scope of work and composition of the HFWG should be tailored to the needs of the system being acquired. Possible members of the HFWG are shown in Figure 3-2. After the contract is awarded, the contractor's Human Factors Engineer may be appointed as deputy chair of the HFWG.

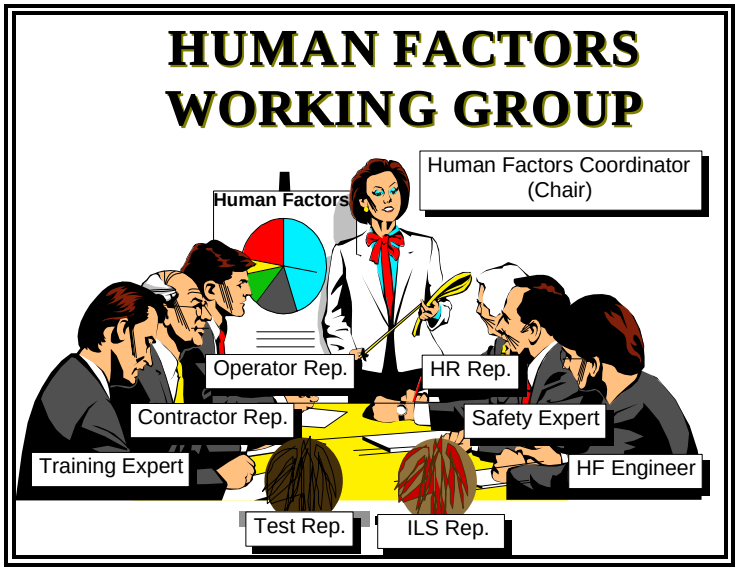

Figure 3-2. HFWG Participants.

Step 2: Review System Operation and Maintenance Concepts

With reference to the initial planning documents such as the Requirements Document, Investment Analysis Report and Acquisition Program Baseline, the system's operational scenarios drive the required operator and maintainer tasks. Performance standards for these tasks will define the staffing and training requirements. The assessment of human performance issues should address:

- Numbers of systems and configurations to be purchased
- Location, physical environment, and work space
- Operational conditions and limitations for the system
- Operational scenarios, training, and procedures
- Maintenance approach and procedures
- Safety and health hazards.

Step 3: Describe the Operators and Maintainers (Staffing and Training)

Develop a profile of the people who will operate, maintain, and support the system. This is often called a ***target population description***. These are the people for whom the system should be designed. Characteristics used to describe this population include numbers of people available, skills, organizational structure, location, training history, aptitudes, and anthropometric data. An assessment should be made of any inconsistencies between the target population and the task performance requirements of the new system. This is a particular issue when the target population is already in place rather than to be hired or selected. Identify the training course requirements including end-of-course testing and scoring necessary for operators/users, maintainers, and supervisors.

Step 4: Identify

The human factors effort should focus not only on the specific tasks involving the system hardware

Operator and Maintainer Tasks

and software interface for users, but also on the operational context in which the user must employ the system. This context can have a particular impact with respect to workload and situation awareness. Generally, the predecessor system, if any, is a good source for functions that the system will perform along with the human interfaces associated with those system functions. Information on the operational context for the system users and those tasks that require additional staffing, skills, or training to perform may also be derivable from this source. These are commonly referred to as ***high driver tasks***. The Human Factors Program should address acquiring and applying information to system design to mitigate the impact of these high driver tasks on task performance and error rates with the new system.

As the system evolves, operations and maintenance tasks should be stated in operational terms of time and accuracy of task performance. Measures of effectiveness or performance should be devised to verify the system's overall operational performance.

Step 5: Identify Human Factors Program Issues

The preceding steps have defined what operators, maintainers, and other users must do under what conditions. In this step, the potential risks or enhancements to system and human performance that pertain to the operational and maintenance tasks of the system being acquired should be identified. Constraints and limitations on human

resources should be addressed. Some examples of issues are:

- Will the new system require additional staffing?
- Will the new system require new skills to operate and maintain the system that do not currently exist in the work force?
- Will the system require the work force to conduct training different from that currently mandated?
- Will the target population user be able to vector xxx number of aircraft within yyy time for periods of up to zzz hours with no errors in maintaining separation?

Potential human factors study areas are listed in Appendix E. The identification of issues should include:

- A full description of the issue
- The problem or risk associated with the issue
- The consequence(s) of not resolving the issue
- Steps to be taken to resolve the issue
- Status of the corrective action(s).

Step 6: Describe Human Factors Program

Given the number and nature of the issues to be resolved, the HFC identifies the major human factors objectives and what tasks and activities must be accomplished to execute the Human Factors Program. The HF objectives should include

Objectives, Activities, and Test & Evaluation Events

meeting required performance levels, reducing errors, minimizing or eliminating safety risks, controlling total workload, and other system relevant HF goals. The Human Factors Program tasks and activities constitute the essential elements of a plan for the execution of the human factors effort. This Integrated Human Factors Plan (IHFP) describes the government's approach to identifying, mitigating, or resolving human factors issues, and may be incorporated in the product team's Integrated Program Plan (IPP). It also includes those tasks and activities that are to be conducted by the vendor and/or integration contractor (further documented in the Statement of Work and documented in the vendor's/ contractor's Human Factors Engineering Plan, as discussed in Chapter 7).

Some examples of human factors tasks and activities include:

- Schedule for coordination and integration activities (such as meetings of the HFWG and analyses to be conducted)
- Research, studies, and analyses that need to resolve unknown human-system performance characteristics of the requirements, alternative solutions, or design
- Prototype development efforts to define and refine the statement of the system requirements or design

- Specifying the human factors portions of the Statement of Work and System Specifications to be used in the Screening Information Request (SIR) or other procurement vehicle
- Points during the acquisition process at which human-system performance will be evaluated or at which Human Factors Program progress will be assessed and refined.

The test and evaluation studies needed for assessment of the adequacy of system HF issues and design changes should be defined. The anticipated scope, user groups, schedule and resources should be developed in consultation with the line of business for the system, the FAA Technical Center Test Directorate and vendors when appropriate. Test and evaluation studies with end users should be tailored to the system requirements as flexibly and economically as possible using approaches such as:

- Studies to describe and develop the human and system performance baselines
- Rapid prototyping
- Simulation
- Operational Field Studies/Task Performance Analyses/ Surveys
- Operational Capability Demonstrations and Formal Test and Evaluation.

End users may also be involved in reviews of functionality, performance requirements and system hardware/software user interface specifications.

Step 7: Devise a Human Factors Program Strategy

The approach taken to achieve the Human Factors Program objectives will vary with the size, cost, and complexity of the system being acquired. Different strategies are appropriate for nondevelopmental items (NDI) and commercial-off-the-shelf (COTS) acquisitions as compared to full developmental efforts. Some systems may need more or different human factors support when focused on requirements definition than on influencing the design during the system engineering process. To accommodate both the number and type of skills needed to support the program during its lifecycle, an overall strategy to acquire the necessary human factors support must be devised. Consideration should also be given to such concerns as:

- The level of support to be rendered by the government versus the contractor
- The equipment, data sources, and facilities needed
- The funding and other resources required
- The schedule for human factors tasks and activities

- The FAA organizations that will participate in the HF portions of the program, with special emphasis on end-user and union involvement
- The relationship with other program developments and requirements.

Step 8: Tailor and Iterate the Human Factors Program

Because each system acquisition program is unique in its pace, cost, size, complexity, and human interfaces, the Human Factors Program should be tailored to meet program demands. As the system progresses through the lifecycle phases of the acquisition process, changes will occur. The Human Factors Program must be structured and maintained to change iteratively with the system. To aid in the management of the Human Factors Program, the HFWG should maintain the Integrated Human Factors Plan (IHFP) document as a living document, incorporating such changes and revisions as are indicated by evolving HF system issues and concerns. Information that should be included in the IHFP include:

- Purpose, scope, and objectives of the IHFP
- HF organization, role, and responsibilities
- HF strategy, approach
- System/program description
- Program background information.

A recommended format and content for such a document is shown in Table 3-2.

TABLE 3-2. INTEGRATED HUMAN FACTORS PLAN (IHFP) CONTENT AND FORMAT		
Headings		**Content**
Introduction	Purpose Scope	• Identify the purpose of the IHFP • Describe the application of the plan and HF program
Strategy	Objectives	• Specify the HF objectives of the system/program
	Goals and Requirements	• Provide the strategy derived from the major concerns, issues, schedule, tasks, guidance, constraints, objectives, and approach for the Human Factors Program • Answer the question, "What objectives does the government wish to achieve?" • Answer the question, "How will the government accomplish these objectives?"
	Constraints	• State any staffing limitation for the new system • Identify guidance concerning whether an existing job series will be used or a new one created • Post limits on the amount of time that can be afforded for training • Identify established standards on the working conditions that will be acceptable when the new system is fielded • Identify limitations imposed by maintenance policy • Describe requirements as a result of union agreements
	Approach	• Specify the general approach(es) to be taken • List significant HF milestones for system describing the duration of major HF activities and the points at which user input or evaluation is required • Define who will be responsible for specific activities in the system Human Factors Program • Describe the extent of vendor HF support required for development of user interface • Specify research questions that need to be answered to resolve critical HF issues • Specify how products of human factors activities and studies including those from outside sources will be used to assist HF Program requirements
Organization	Human Factors Point of Contact HF Resources HF Organization	• Designate the program point of contact for human factors • Specify the resources support the HF effort • Identify the organizational structure of the HF resources. Define how human factors resources will be organized and managed to support the system acquisition. Resources should

		be specified for the HF personnel required to execute the activities of the system HF Program, outside facilities and personnel such as the FAA Technical Center, analytical and developmental tools, test and evaluation facilities, simulators, field sites, test instrumentation, survey and data collection forms
	Roles and Relationship	• Describe the roles of the HF resources and their relationship with other elements of the program
Program Background	Program Summary	• Describe the program including system capabilities and features
	Operational Concepts	• Summarize the concept of operation and maintenance to include operational scenarios, performance requirements, and interaction with other lines of business
	Program Schedule	• Provide an overview of system acquisition schedule including key dates affecting the HF Program
	Target Population Description	Describe the affected user population (operator and maintainer) for attributes such as: • Demographics • Biographical data • Previous training • Aptitudes • Task-related experience • Anthropometric data • Physical qualifications • Organizational relationships • Work space requirements (Use an appendix if data are lengthy)
HF Risks and Opportunities	Potential HF Engineering Issues, Risks, Problems, and Enhancements	Describe the potential HF issues, risks, problems, or enhancements. Include the background, importance, and consequences to the acquisition. Identify both the probability and severity of the risk or potential enhancement
HF Tasks	Tasks and Activities	• Identify the tasks and activities that need to be conducted to support the objectives of the human factors program • Include all activities necessary to identify and resolve human factors issues • Include all tasks and activities associated with Mission Analysis, Investment Analysis, Requirements Determination, System Analysis, System Design and Implementation, System Test and Evaluation, Post Deployment Assessments, System

		Upgrades, and In-Service Management • Identify any tasks, research, studies, or analyses that must be performed to resolve the issues (e.g., Human Performance research to establish baseline performance levels, SOW and specification input to procurement documents, human engineering program plan per MIL-HDBK-46855, Functional Analysis to support equipment vs. people allocation of functions, Task Analysis to produce a specific operator and maintainer task list) • Identify relevant Human Factors activities and studies performed by other organizations (IPTs, contractor, FAA Aviation Research, other government agencies)
	Activity Schedule	• By acquisition phase, describe the human factors tasks and activities in terms of who, what, when, and how (resources) • Identify feeds to and dependencies on ILS, training, and test and evaluation programs
	Issues Status	• Specify the monitoring process for key HF requirements and progress status • Show the current status of each issue (use an appendix as necessary)
	Test and Evaluation	• Identify HF critical operational issues and criteria (COIC) • Provide performance measures and criteria in terms of time and accuracy (or other measures) to perform tasks to evaluate resolution of issue • Identify the kind of system tests and assessments requiring end user input • Identify all assessments, demonstrations, test, and evaluations including: – Functionality review – Performance requirements review – System interface review – Rapid prototyping evaluation – Operational demonstration – Simulation assessment – Field assessment – Formal test and evaluation
IHFP Tailoring and Updating	Review	• Identify administrative handling procedures • Identify update schedule and procedure • Identify review procedures

	Revise	• Identify activities that require changes to actions, resources and schedule • Revise changed activities and assess whether change in one activity will force changes in others
	Post Fielding	• Measure human-in-the-loop system performance to determine if performance standards achieved • Survey users to determine if human system integration meets expectations • Determine need for system enhancement or modification • Identify lessons learned during program execution • Identify system deficiencies to serve as basis for future requirements documents
Additional Information	References	• Identify relevant references needed for a full understanding of the Human Factors Program (Use an appendix if appropriate.) • MIL-HDBK-46855, Human Engineering Program Process and Procedures • FAA HF-STD-001, Human Factors Design Standard • FED STD-795, Uniform Accessibility Standards
	Appendices	Provide appendices as required

CHECKLIST QUESTIONS

- Has a Human Factors Coordinator (HFC) been appointed?
- Does the HFC have the appropriate human factors expertise and training?
- Does the Human Factors Working Group (HFWG) membership represent each activity having significant human factors interest in the system?
- Have the HFWG operating procedures been approved?

- Have operation and maintenance concepts been adequately reviewed for human factors implications?
- Has the operator and maintainer target population been adequately described?
- Have the performance parameters of operator and maintainer tasks been adequately identified?
- Is there an adequate procedure for all significant unresolved human factors issues to be brought to the IPT's attention?
- Have all appropriate human factors tasks, activities, and objectives been identified and resourced?
- Has a strategy for the Human Factors Program been developed that is consistent with the size, cost, and complexity of the system being acquired?
- Are procedures established for revising the Human Factors Program when necessary?

SAMPLE HFWG OPERATING PROCEDURES

1. INTRODUCTION: These operating procedures establish the System X Human Factors Working Group and prescribe its responsibilities and operating procedures. The System X HFWG will contribute to the total system performance of System X by ensuring that all relevant information concerning human factors is continuously integrated into the System X development and acquisition process. The HFWG will provide the comprehensive management and technical effort necessary to achieve a fully effective Human Factors Program.

2. PURPOSE: The purpose of the System X HFWG is to assure that all human factors issues and concerns are identified and successfully addressed during the course of system development.

3. RESPONSIBILITIES: The System X HFWG will:

a. Assist in integrating the human factors effort with the system engineering effort,
b. Coordinate the development, review and execution of the System X Human Factors Program,
c. Provide a forum for direct communications between members to identify and address human factors requirements, objectives, concerns and issues,
d. Identify needed human factors tasks and activities and review the results thereof,
e. Review contract deliverables for human factors implications,
f. Provide recommendations concerning human and system performance,
g. Ensure unresolved issues are surfaced to appropriate decision makers and propose the action to be taken to resolve those issues,
h. Maintain an audit trail of human factors activities and decisions,
i. Coordinate with appropriate human factors-related entities.

4. PROCEDURES: Meetings of the HFWG will be held at the times and frequencies deemed appropriate by the Chair. The Chair will provide for the recording and distribution of minutes of all meetings. Each member will be notified of the time, place and agenda for each meeting, normally not less than ten working days prior to the meeting. Members will be responsible for ensuring their own and supplemental representation (approved by the Chair) as may be required by the agenda. The Chair will maintain an Action Item log with suspense dates; responsibility for each action will be assigned on the basis of functional areas and expertise. Each action item will be reviewed and the status updated at every HFWG meeting. The Chair, if required, will establish subcommittees.

5. MEMBERSHIP: The representatives to the HFWG will include those personnel so designated by the member agencies. The organization of the HFWG will include:

a. Chair. The IPT Human Factors Coordinator will serve as the Chair. The contractor's Human Factors Representative may serve as Deputy Chair.

b. Members. Primary or alternate representatives will be present at each HFWG meeting. The designated member from each organizational element will be the spokesperson for that organization. Non-member activities that have human factors responsibilities or interests may be invited to attend meetings. HFWG membership is listed by agency or activity in the enclosure (list membership by specific agency or activity with address and phone numbers, etc.).

Chapter 4 Human Factors in Mission Analysis and Requirements Development

PURPOSE

The purpose of this chapter is to provide basic guidelines for the development of human factors requirements. Human factors (HF) requirements are often poorly stated in the flow of documents related to system acquisitions. Human factors input to documentation during and subsequent to a Mission Analysis (MA) must provide essential elements of information upon which to build good requirements; prepare cost, benefit, and risk analyses; conduct studies and analyses, and develop plans, specifications, and statements of work.

Human factors requirements are intended to ensure that equipment operated or maintained by the FAA is easy to operate, maintain, and train. The FAA Human Factors Design Standard (HFDS) provides detailed guidelines and conventions to achieve a human-centered, error resistant, error tolerant, operationally effective, operationally suitable, and usable system. Human factors requirements must address:

- Human-system interfaces that impact on user performance efficiency and effectiveness

- System architecture design that impacts on human-system interfaces
- Human-systems considerations that impact human resources and systems outside the boundary of the system being acquired.

Timing

HF input to the Mission Analysis is reflected in the Mission Need Statement (MNS) which defines a mission capability shortfall or technological opportunity the FAA should address and includes consideration of major human resource and human-system performance issues.

The MNS is prepared in the Mission Analysis phase. Joint Resources Council (JRC) approval of the MNS initiates entry into the Investment Analysis phase. The MNS is revalidated at the Investment Decision. Incorporation of major human resource and performance considerations provides a basis for addressing constraints related to the human component of the required capability.

HF considerations are incorporated into Mission Analysis products to identify capability shortfalls or opportunities for enhancement of human-system performance. HF requirements are developed during the Integrated Requirements Team (IRT) activities and incorporated into the initial Requirements Documents (iRDs) and final Requirements Documents (fRDs).

Requirements are developed early in the investment analysis process by the sponsoring organization. Capability shortfalls or technological opportunities identified in the MNS are translated into essential top level operational and functional requirements. An initial Requirements Document (iRD) is prepared and updated during the Investment Analysis phase. Requirements evolve into greater specificity throughout the process to support detailed market, investment, and affordability analyses.

The iRD establishes the baseline criteria for selecting candidate solutions, conducting market analyses, analyzing alternatives, and performing affordability assessments to provide the best overall approach for satisfying the mission need.

Throughout the alternatives and affordability assessment phases of the investment analysis process, requirements are evaluated against cost, benefit, schedule, and performance considerations. Requirements that are descriptive enough of what is being asked of industry to satisfy (via a contract or other government vehicle) will be provided to the IA Team to conduct the market analysis.

Human factors inputs to the Requirements Document identify requirements for human performance factors that may impact system

design. Broad cognitive, physical, and sensory requirements for the operator, maintainer, and support personnel that contribute to or constrain total system performance are established. Any safety, health hazards, or critical errors that reduce job performance or system effectiveness are defined. The staffing and training concepts and constraints are also described.

"HOW TO"

Human factors practitioners have found utility in general and specific guidelines for supporting mission needs and requirements development activities.

General Guidelines

Human factors practitioners are expected to participate in IRT activities to provide essential expert input for the development of requirements documents. These guidelines are general in nature and apply without regard to specific AMS policy/processes that may require tailoring of human factors requirements. Consideration should be given to the following.

- Human factors requirements developed early in a program will likely need greater specificity later in the program. However, even requirements in the fRD may not sufficiently define the specific measures, performance values, thresholds, or data collection requirements that will be needed to verify the requirement during test and evaluation.

- Some requirements may evolve to near specification-like details especially for critical issues. They may be complemented by SOW-type requirements for conducting activities (analyses/studies) to define the specification-like details or government requirements for the same.
- There is a direct and devolving relationship between the Critical Operational Issues (COIs), requirements, Specs/SOW, and test and evaluation plans. Quality in one determines the quality of the next.

Specific Guidelines

- Limit the number of different reference documents used to avoid adding cost to the contract and vendor. Use HFDS as a basic reference (especially, in place of MIL-STD-1472).
- Consider including requirements for major study areas that are likely to affect human-system performance such as those listed in Appendix E.
- Be as precise and specific as possible so that the requirement can be adequately translated into performance criteria and addressed during "test and evaluation." (This is less important for an iRD that may not have the same degree of specificity as an fRD.)
- Specify or refer to human-system performance levels wherever possible.

- If the system interfaces with other (new or existing) systems, consider requiring the "use of" or "compliance with" other existing standards, CHI, guidelines, symbols, or lessons learned. This helps avoid re-inventing the HF "wheel."
- If the requirement is non-specific or requires explanation, provide a descriptive "note" below the requirement to provide the background or rationale. Notes are not considered requirements and are not binding in any way, but may offer an explanation or rationale for the requirement that will assist the IPT to pursue the objectives of the requirement.
- HF requirements should be derived in accordance with what people have to do (especially in Section 3 of the RD) to ensure that the human-system performance will meet expectations.
- To comply with the database documentation rules for requirements, use one requirement statement per paragraph number, and employ subject-predicate format with simple sentences and with no compound predicates.

Step 1: Human-System Performance Analysis

The first step in the development of HF requirements is to analyze the system, system context, and to acquire the relevant system knowledge. Possible knowledge sources are:

- Results of Mission Analysis and Mission Need Statement
- Results from Functional Analysis
- Operational and Maintenance Concepts; Context of Use
- Predecessor system information (e.g., procedures, work-arounds, trouble reports, lessons learned)
- Research, studies, and analyses
- Other acquisition oriented studies (e.g., trade studies, market surveys, cost and benefit analyses)
- Subject matter expertise

Step 2: Integrate HF Principles into System Context

The second step is to integrate HF principles into the system context and formulate HF requirements. In this step HF requirements are initially formulated before they are formalized and finalized in step 3 of the process.

In developing or modifying the Human Factors portion of either the iRD or fRD, it is recommended that the Human Factors practitioner attend as many of the requirements team meetings as possible. This is essential to fully understand the intended function of the system and concept of operations and to be privy to changes to these that may evolve during Requirements Team meetings. Other team members often provide valuable information and insight on issues pertinent to human factors.

Human factors requirements shall provide information and guidelines concerning common human factors study areas listed in Appendix E.

Step 3: Prepare Human Factors-Requirements for AMS Requirements Document

The formalization of human factors requirements for the AMS requirements documents may include performance and detailed requirements in Section 6 (Human Integration) of the Requirements Document as well as Critical Operational Issues for the program.

The following are candidate Human Factors Critical Operational Issues (HFCOIs) to be used in requirements documents and in test and evaluation plans:

- Can the operator/maintainer/supervisor perform the required tasks to the expected level of performance with the minimum required training in all operational conditions and environments? OR,
- Can the operator/maintainer/supervisor perform the required tasks with at least the same effectiveness as the current systems with the minimum required training in all operational conditions and environments?

  OR,
- Is the system operationally effective, suitable, and maintainable in its operational environment?

The following may serve as Human Factors

Additional Critical Operational Issues (HFACOIs) to be used in requirements documents and test and evaluation plans to supplement Human Factors COIs:

- Do the user training and qualification, operational concepts, procedures, and human-system designs support safe and effective operations for the user?
- Does error management (e.g., prevention, detection, and recovery) for the user support effective and safe operations and maintenance?
- Are the system-human interfaces designed/developed to provide integration and consistency with other technologies and systems employed by the user?

A Human Factors template for the requirements document is provided at Table 4-1.

Table 4-1 Human Factors Requirements Template

6.0 HUMAN INTEGRATION

6.1 Human Systems Engineering

Human Factors <u>*shall*</u> be addressed in the design, development, and test of the XYZ System in accordance with FAA Order 9550.8 *Human Factors Policy*.

Note: The goal is to use human-centered design processes that will result in efficient, effective, user acceptable system interfaces that will be simple to train, use, and maintain.

6.1.1 Human Factors Program

A Human Factors Program <u>*shall*</u> be established for XYZ in accordance with the *FAA Human Factors Job Aid*.

Note: The FAA Human Factors Job Aid is a guide to the development and conduct of the FAA Program Office/ IPT Human Factors Program for a system development.

6.1.1.1 Development Contractor's Human Engineering Program

The XYZ System development contractor *shall* conduct a Human Factors Engineering Program in accordance with MIL-HDBK-46855A, *Human Engineering Program Process and Procedures*, Section 4 "Program Tasks" and Section 7 "HE Procedures for Contractors."

Note: The reference provides requirements for Human Factors planning, analysis, design, and testing activities. This will become an SOW requirement.

6.1.2 Task Analysis

XYZ System task analyses *shall* be in accordance with MIL-HDBK-46855A, *Human Engineering Program Process and Procedures*, Section 8 "HE Methods and Tools."

Note: As the fRD becomes more refined, the Human Factors practitioner(s) should add definition to the Task Analysis methods and tools to be used. These will become SOW items.

6.1.3 Human Factors Design Standard

The XYZ System *shall* be in accordance with DOT/FAA/CT-96/1 *Human Factors Design Standard for Acquisition of Commercial-Off-the-Shelf Subsystems, Non-Developmental Items, and Developmental Systems* (HFDS).

Note: The HFDS applies to COTS and NDI, as well as to developed items. With respect to COTS and NDI, the HFDS sets forth design criteria against which candidate components/systems are to be evaluated. In the event that modification of a COTS or NDI item is feasible and cost justifiable, the HFDS criteria are to be used in developing those modifications.

6.1.3.1 "Other Design Standards"

The XYZ System *shall* be in accordance with "Design standard XXXXXXX."

Note: As requirements gain definition, other human factors design standards may be identified for application to the XYZ System. These can be

added as subparts to 6.1.4. For example, if the system incorporates a weather display, a requirement could be added as 6.1.4.1 Weather Situation Display Symbology to invoke ACB2202002-02 User Interface Designs for Advanced Weather Products of Terminal Air Traffic Control Displays.

6.1.4 Human-Centered Design

XYZ human-to-system interfaces ***shall*** be in accordance with human-centered design processes.

Note: These processes are described in the FAA Human Factors Awareness tool, "Usability" section at the FAA Human Factors Home Page. They can also be found within ISO 13407 (Feb 96): "Human-centered design processes for interactive systems."

6.1.4.1 Usability

The XYZ human-system integration ***shall*** be in accordance with the HFDS, Chapter 3.1 *General* and 3.2 *Design and evaluation*.

Note: Usability refers to ease of use which addresses the perceptual and physical characteristics of the human-system interface and includes general issues regarding the ability of users to operate the system as well as to read, detect, access, and manipulate information. The metrics for usability are performance measurements, expert assessment ratings, and user feedback, as part of the human-centered design process.

6.1.4.2 Operational Suitability

XYZ human-to-system interfaces ***shall*** be compatible and consistent within and across system and NAS elements in accordance with the HFDS, Chapter 2.4 S*tandardization* and 3.1 *General*.

Note: Operational Suitability broadly refers to the capabilities of a system to support all operational tasks including support of all problem solving and decision making tasks of the user. Operational Suitability implies the appropriateness of the functionality and the effectiveness of the system to support situation awareness and information, error, and workload management. As the system requirements evolve, the other systems in the NAS with which the XYZ System must share human-to-system interface consistency must be specified. The design goal is to eliminate the need for users to "learn" different, and perhaps conflicting, system interfaces and interactions.

6.1.4.3 Function Allocation
XYZ System function assignment to humans (users) *shall* be in accordance with the HFDS, revised Chapter 3.11 *Function allocation/levels of automation*.

> *Note: Function allocation is an element within the System Engineering process. The metrics to assess compliance with this requirement are analysis and inspection with comparison against published standards for human perceptual and cognitive capabilities and limitations, such as Lincoln & Boff, "Engineering Data Compendium: Human Perception and Performance," 1988.*

6.1.4.4 Human Capabilities and Limitations
XYZ System displays and attendant commands and controls *shall* be compatible with human perceptual and cognitive capabilities and limitations in accordance with the HFDS, Chapter 3.4 *Interface*.

> *Note: The metrics to assess compliance with this requirement are analysis and inspection with comparison against published standards for human perceptual and cognitive capabilities and limitations, such as Lincoln & Boff, "Engineering Data Compendium: Human Perception and Performance," 1988.*

6.1.5 Human-to-System Interfaces
The XYZ human-to-system interfaces *shall* be in accordance with the HFDS, Chapter 2 *General design requirements*.

6.1.5.1 Design Simplicity
The XYZ human-to-system interfaces *shall* be designed for simplicity of use in accordance with the HFDS, Chapter 2.2 *Simplicity*.

> *Note: The metrics for design simplicity include number of procedures, number of steps in a procedure, number of input device activations, number of decision points, and entry redundancy. These are assessed during the human-centered design process.*

6.1.5.2 Identical Functions
XYZ System equipment with identical functions *shall* employ identical or highly similar human-system interfaces, including hardware and software tools, in

accordance with the HFDS, Section 2.3 *Consistency*.

Note: The intent of this requirement is to increase user efficiency and accuracy and decrease confusion by not requiring the user to learn multiple, different interfaces for the same or similar function. Compliance with this requirement will be determined by analysis and inspection.

6.1.5.3 Situational Awareness

XYZ System information displays shall meet situational awareness requirements in accordance with the HFDS, Section 3.12 *Information automation*.

Note: The design goal is to support and reinforce user situational awareness at all times.

6.1.6 Communications and Teamwork

XYZ System *shall* enable personnel communication and information interchange in accordance with the HFDS, Section 3.2.3 *Consider effects on coordination*.

Note: The design goal is to enable and facilitate inter-user communications, for example between air traffic controllers, air traffic controllers and pilots, maintainers, and maintainers at remote sites.

6.1.7 Automation Guidelines

XYZ human-to-system interfaces *shall* comply with the HFDS, Chapter 3 *Automation.*

6.1.7.1 Fail Safe Design

XYZ System human-to-system interfaces *shall* be analyzed for system safety and personnel safety hazards in accordance with ASD-100-SSE-1, *NAS Modernization System Safety Management Program*.

6.1.7.2 Human Error Resistant

XYZ human-to-system interfaces *shall* be human error resistant in accordance with the HFDS, Section 2.5.3 *Make systems error resistant*.

Note: The metric for compliance with this requirement is the conduct of a Human Error Analysis (HEA), based on the Task Analysis. The goal is to "design out" the potential for human error to adversely affect system and personnel safety.

6.1.7.3 Human Error Tolerant
XYZ human-to-system interfaces *shall* human error tolerant, in accordance with the HFDS, Section 2.5.4 *Make systems error tolerant*.

> *Note: The method assessing compliance with this requirement is the conduct of a Human Error Analysis (HEA), based on the Task Analysis. The design goal is for the system to recognizing inappropriate user actions and providing specific feedback on errors.*

6.1.7.4 Infrequent Critical Tasks
XYZ human-to-system interfaces *shall* be designed for ease of handling infrequent, critical situations and emergencies in accordance with the HFDS, Section 2.5.7 *Provide emergency procedures for critical systems*.

> *Note: The design goal is for the system to be easy to use in situations in which human proficiency may have degraded because of infrequent performance of a task. The metrics for this requirement are time to perform and accuracy of performance for tasks and procedures deemed system or personnel safety critical. Tasks and procedures will be defined as system or personnel safety critical as a result of the NAS Modernization System Safety Management Program, ASD-100-SSE-1.*

6.1.7.5 Automation Function Indications
The XYZ System *shall* provide indications when automation functions enabled and when they are disabled in accordance with the HFDS, Section 3.3 *System response and feedback* and 3.6 *Modes*.

> *Note: The operational need is for users to readily understand that a particular part or parts of the automation are not working.*

6.1.7.6 Degraded Mode Operation
XYZ System interfaces *shall* be designed to enable efficient, accurate use during degraded modes (when one or more functions are disabled) in accordance with the HFDS, Section 3.6.6 *Provide consistent features and functions*.

> *Note: The metric for efficiency will be time to perform tasks in degraded mode, compared with time to perform tasks in non-degraded mode. The metric for accuracy will be errors and severity error consequence in degraded mode, compared to errors in non-degraded mode.*

6.1.7.7 Fault Management
XYZ System automated diagnostics aids *shall* enable fault management and system failure recovery through timely user notification of specific failures or potential failures in accordance with the HFDS, Section 3.8 *Fault Management*.

6.1.8 Computer-Human-Interface Requirements
XYZ computer-to-human interfaces *shall* be in accordance with the HFDS, Chapter 8 *Computer human interface*.

6.1.8.1 Screen Design
The XYZ System screen designs shall be accordance with the HFDS, Section 8.1 *Screen Design*.

6.1.8.2 Visual Coding
XYZ System visual coding *shall* be in accordance with the HFDS, Section 8.6 *Coding*.

6.1.8.3 Color-Coding
XYZ System color-coding *shall* be in accordance with the HFDS, Section 8.6 *Coding* and Section 8.6.2 *Color*.

6.1.8.4 Redundant Coding
XYZ System color-coding *shall* have a second, redundant coding dimension in accordance with the HFDS, Section 8.6.2.1.5 *Redundant use*.

6.1.8.5 Auditory Alerts and Alarms
XYZ System alarms and alerts *shall* be in accordance with the HFDS, Chapter 7 *Alarms, audio, and voice communications.*

6.1.8.6 User Interaction
The XYZ user-to-system interactions *shall* be in accordance with the HDFS, Section 8.7 *Interaction* and 8.8 *General interactive techniques*.

6.1.8.7 Systems Operations
The XYZ human-to-system interfaces *shall* be in accordance with the HFDS Section 8.15 *System operations.*

6.1.8.8 System Response Time
The XYZ System *shall* provide feedback if system response to a control action is greater than 2 seconds in accordance with the HFDS, Section 8.15.6 *System response time*.

6.1.8.9 On-Line Help
The XYZ System *shall* provide context sensitive, on-line help in accordance with the HFDS, Section 8.16.1 *On-line help* and 8.16.4 *Context sensitivity*.

6.1.9 Workstations
XYZ System workstations *shall* be in accordance with the HFDS, Section 10 *Workplace design*.

6.1.10 Displays
XYZ System displays *shall* be selected in accordance with the HFDS, Chapter 5 *Displays and printers*.

6.1.10.1 Readability
XYZ System displays *shall* be readable from the position from which they will be used in accordance with the HFDS, Section 5.1.2 *Location and arrangement*.

> *Note: Display readability can be calculated from viewing distance, character size, contrast, and visual angle (viewing position). These calculations can be verified by user testing in a Human Factors laboratory or operational installation.*

6.1.11 Displays and Controls
XYZ System displays and controls *shall* be in accordance with the HFDS, Chapter 6 *Control and visual integration.*

6.1.11.1 Input Devices
XYZ System input devices *shall* be in accordance with HFDS, Chapter 9 *Input devices*.

6.1.12 Maintainability

XYZ maintainer-to-system interfaces *shall* be in accordance with the HFDS, Chapter 4 *Designing equipment for maintenance*.

6.1.13 Labeling
XYZ System equipment labeling *shall* be in accordance with HFDS, Section 4.3.5 *Labeling and Marking*.

6.1.13.1 Safety Labels
XYZ System equipment safety labeling *shall* be in accordance with the HFDS, Section 12.16 *Safety labels and placards*.

6.1.14 User Documentation
XYZ System user documentation *shall* be in accordance the HFDS, Chapter 15 *User documentation*.

6.1.14.1 Technical Manuals
XYZ System technical manuals *shall* be in accordance the HFDS, Chapter 15 *User documentation*.

6.2 Employee Safety and Health

The XYZ System personnel safety *shall* be in accordance with FAA Order 3900.19B *Occupational Health and Safety Program,* the HFDS Section 12 *Personnel Safety,* and FAA-G-2100G *Electrical Equipment, General*.

> *Note: FAA Order 3900.19B requires adherence to 29 CFR 1910, Occupational Safety and Health Standards for General Industry and 29 CFR 1926 Safety and Health Regulations for Construction.*

6.2.1 Anthropometry and Biomechanics
XYZ human-to-system physical interfaces *shall* be in accordance with the HFDS, Chapter 14 *Anthropometry and biomechanics*.

6.2.2 Maintainer Workspace

XYZ System maintainer physical and visual access *shall* be in accordance with the HFDS, Section 4.3.4.1 *Physical accessibility* and 29 CFR 1910.303 *Electrical*.

6.2.2.1 Access to Serviceable Components
XYZ System Lowest (Line) Replaceable Units *shall* be accessible and removable at the equipment's operational location in accordance with the HFDS, Section 4.3.4 *Positioning equipment*.

6.2.2.2 Critical Item Location
XYZ System critical items *shall* be accessible in accordance with the HFDS, Section 4.3.4.2 *Relative accessibility*.

> *Note: The intent is for items that are the most critical for system operation to be placed in the most accessible locations to enable rapid maintenance action.*

6.2.2.3 High Failure Rate Item Location
XYZ System high failure-rate items *shall* be accessible in accordance with the HFDS, Section 4.3.4.2 *Relative accessibility*.

6.2.2.4 Equipment Mounting
XYZ components *shall* be mounted in accordance with the HFDS, Section 4.3.3 *Mounting in drawers, on racks, and on hinges*.

6.2.3 Human Lifting and Carrying Limitations
XYZ System equipment that is to be manually handled *shall* be in accordance with the one person lift limitation in the HFDS, Section 4.2.*Designing Equipment for handling*.

> *Note: The goal is to configure items to be manually- handled so that they can be lifted and carried by one person. If this is not possible then a lifting device is to be provided.*

6.2.3.1 Handles
XYZ System equipment that must be manually handled *shall* be in accordance with the HFDS, Section 4.2.5 *Handles*.

6.2.4 Working Environments

XYZ System working environment(s) *shall* be in accordance with the HFDS, Chapter 13 *Environment*.

6.2.4.1 Ventilation, Temperature, and Humidity

XYZ System working environment(s) *shall* be in accordance with the HFDS, Section 13.2 *Ventilation* and Section 13.3 *Temperature and Humidity*.

6.2.4.2 Illumination

XYZ System working environment ***shall*** be illuminated in accordance with the HFDS, Section 13.4 *Illumination*.

Note: The operational need is for effective, efficient, and safe task performance. General and supplemental illumination is to be provided to satisfy this need.

6.2.4.3 Noise

XYZ System generated noise ***shall*** be in accordance with the HFDS, Section 13.5 *Noise*.

Note: The XYZ System shall not generate noise that causes the work environment to be in excess of the limits defined in the HFDS, Section 13.5.2 Non-hazardous sound levels.

6.3 Specialized Skills and Capabilities

XYZ System shall be operable and maintainable by the current work force, as verified by a Task and Skills Analysis.

Note: The design goal is for no additional specialized skills and capabilities to be required. This does not preclude new "knowledges" acquired through training.

6.3.1 Workload

XYZ System operator and maintainer cognitive and physical workloads ***shall*** be accordance with the HFDS, Section 3.1.11 *Avoid extreme workload levels* and Section 3.1.10 *Avoid increasing demands for cognitive resources*.

Note: Metrics for workload are number of tasks performed and decision complexity, as well as task performance times and error rate variance over the workday and under differing operational conditions.

6.3.2 Staffing

XYZ System staffing levels ***shall*** be in accordance with a personnel staffing analysis.

Note: The objective is to eliminate adverse impact on staffing levels.

6.3.3 Training

XYZ System *shall* be in accordance with the HFDS, Section 3.1.24 *Make systems easy to learn* and Section 3.10 *Training*.

Note: The metrics for this requirement include training time, time to proficiency, and refresher training requirements to avoid skill decay. The key concept is that the complexity of the operator or maintainer interface directly affects the complexity and duration of training. Well- designed, intuitive, simple interfaces require less costly training devices (simulators) and less training time.

6.4 Accessibility Compliance

XYZ System *shall* be in accordance with FED-STD-795, *Uniform Federal Accessibility Standard (UFAS).*

6.4.1 Section 508

XYZ System's routine administrative and business *shall* be in accordance with 36 CFR 1194, *Electronics and Information Technology Accessibility Standard,* which implements Section 508 of the *Rehabilitation Act of 1973,* as amended (29CFR 794d).

Note: Examples of routine administration and business applications are personnel management or finance related activities.

Note: Under the plain English initiative, the FAA has begun to adopt the use of the word "must" in place of the word "shall" for requirements and other contractual statements. The requirements statements in Table 4-1 reflect the use of "must" so as to maintain consistency with the FAA source document (HF-STD-001, Human Factors Design Standard) which has not yet been revised.

CHECKLIST QUESTIONS

- Has the human factors practitioner been designated to participate in IRT activities?

- Has the Human Factors Design Standard been used as a basic reference?
- Are the requirements specific and precise enough that they can be translated into performance criteria? If not, are descriptive 'notes' added to requirements providing rationale?
- Have the HF areas that are listed in Appendix E been covered sufficiently?
- Are requirements specified in simple sentences and single paragraph format including numbering?
- Do the human factors requirements provide sufficient human-system objectives and guidance for both the contractor and government?
- Does the requirements document include a critical operational issue for human-system performance?

Chapter 5 Human Factors in the Investment Analysis Process

PURPOSE

An investment analysis is conducted to determine the most advantageous solution to an approved mission need. In general, it involves development of operational requirements, conduct of a market survey to determine industry capabilities, analysis of various alternative approaches, and a determination of what the FAA can afford. The purpose of human factors in the investment analysis process is to ensure that:

- Human-system capabilities and limitations are properly reflected in the system requirements
- Human-system performance characteristics and their associated cost, benefits, and risks assist in deciding among alternatives (especially since lifecycle operation and support costs are often largely dependent upon personnel-related costs)
- Human-system performance risks are appropriately addressed in program baselines

"HOW TO"

The investment analysis (IA) must identify for each alternative the full range of human factors and interfaces (e.g., cognitive, organizational, physical, functional, environmental) necessary to achieve an acceptable level of performance for operating, maintaining, and supporting the system in concert with meeting the system's functional requirements. The analysis should provide information on what is known and unknown about the human-system performance risks in meeting minimum system performance requirements.

Human factors considerations that are relevant to meeting system performance and functional requirements during the IA include:

- Human performance, such as human capabilities and limitations, workload, function allocation, hardware and software design, decision aids, environmental constraints, and team versus individual performance
- Training (e.g., length of training, training effectiveness, retraining, training devices and facilities, and embedded training)
- Staffing, such as staffing levels, team composition, and organizational structure
- Personnel selection, such as minimum skill levels, special skills, and experience levels
- Safety and health, such as hazardous materials or conditions, system or equipment design, operational or procedural constraints,

biomedical influences, protective equipment, and required warnings and alarms.

The human factors support to the Investment Analysis Team follows the general process flow for Investment Analyses which includes the investment analysis planning, requirements definition, alternative solution identification and analysis, affordability assessment, acquisition program baseline development, and support for the investment analysis reporting, briefing, and decision. Support is provided by a designated, qualified Human Factors Coordinator (HFC). Table 5-1 describes the general role of the HFC.

Table 5-1 General Role of the Human Factors Coordinator

The Human Factors Coordinator on the Investment Analysis Team provides the support for the integration of human factors engineering in the investment analysis phase of system development and acquisition. The HFC helps the Investment Analysis Team to initiate, structure, direct, and monitor their human factors efforts. The HFC serves with IA Team to identify, define, analyze, and report on human performance and human factors engineering considerations to ensure they are incorporated in investment decisions. Typical human-system performance and human factors engineering studies and analyses conducted, sponsored, or supported by the HFC include requirements analyses, baselines performance studies, trade-off determinations, alternative

operational performance considerations in procedures and other human-system interfaces.

The HFC facilitates the establishment of the necessary tools, techniques, methods, databases, metrics, measures, criteria, and lessons learned to conduct human factors analyses in investment analysis activities.

The HFC provides technical quality control of human factors products to the IA Team, participates in special working groups, assists in team reviews, helps prepare IA documentation, and collaborates on technical exchanges among government and contractor personnel.

Step 1: Formulate HF-Input to Investment Analysis Plan

The Investment Analysis Plan (IAP) provides the planning information necessary for conducting the particular investment analysis in a timely and efficient manner. It must be completed early in the investment analysis phase. The IAP provides:

- The composition of the Investment Analysis (IA) Team
- A schedule for completing the various activities within the investment analysis process
- The assignment of roles and responsibilities for accomplishing the necessary activities
- A list of all alternatives identified and the end set chosen for further analysis as candidate solutions.
- The strategy for conducting the relevant HF IA activities.

The inclusion of human factors in the investment analysis process is dependent upon the groundwork that is laid in the IAP. Human factors

inputs to the IAP include (as available) information about salient human factors issues, how human factors engineering and these specific issues will be assessed, and human factors activities needed to support the investment analysis process. Other information about schedules, costs, assessment criteria, roles and responsibilities may be addressed as appropriate.

Step 2: Estimate HF of Cost, Benefit, and Risk

The costs, benefits, and risks of human factors must be analyzed within the context of the capability being acquired to meet the mission need. Like other attributes of the alternatives, the human factors contribution to the system costs, benefits, and risks should be assessed in both qualitative and quantitative terms, especially as they relate to the measures and criteria established for the alternatives' evaluation.

The type of acquisition will also affect the approach. Thus, the analysis approach taken for NDI/COTS will likely differ from the analysis approach for developmental acquisitions. For example, the former assesses the relative costs, benefits, and risks among solution alternatives or vendor products, while the latter assesses the costs, benefits, and risks among alternative operational and maintenance concepts. Also, the activity timing (when the human factors activity is conducted) and type of data collected may also differ between an NDI/COTS and a developmental program. For

example, in the former, data may be collected during investment analysis (e.g., via market surveys) on the cost and effectiveness of training programs that implement vendor alternatives, whereas, in the latter, data may be collected during solution implementation (e.g., via task analyses) on the critical tasks to be trained.

If it is not possible to collect definitive cost/benefit and human performance data, heuristics and rules of thumb may be employed to provide gross estimates. For example, the funding necessary to conduct a comprehensive human factors engineering program for a system has been estimated to be between 0.5% and 6% of system developmental costs (depending upon the sensitivity of the solution to human factors issues). The benefit from conducting a comprehensive human factors program has been estimated at between 20% to 30% of total acquisition costs. Such rules of thumb may be useful for gross approximations but tend to be a weak substitute for more thorough analyses and data collection.

Step 3: Alternative Solution Identification and Analysis

Conducting the alternative solution identification and analysis entails the following human factors activities:

Alternative Identification: The HFC on the IA Team assists in identifying alternative solutions to meet the desired capability. Having identified the

requirements (in support of the Integrated Requirements Team), the HFC will assist in identifying each alternative's human factors approach for the various types of acquisition and system upgrade solutions (e.g., NDI, COTS), as well as for those that may not entail a material solution. (Non-material solutions include procedural, training, staffing of special skills or abilities, or job or organizational design changes that will achieve the mission need.)

Issue/Risk Identification: Using the alternatives identified, the initial or refined requirements, the predecessor system performance, and the critical operational issues, the HFC establishes a list of the human factors issues (explicit and implied) that potentially have an effect on the performance of the system. Initially these issues may be concerns with broad categories of human-system performance such as manpower requirements, training requirements, human-system effectiveness, and suitability. As the IA Team continues to refine their work, these issues will become more defined and refined. (See Appendix E, Human Factors Study Areas.)

Evaluation Criteria Selection: Using the results of the mission analysis and based on the initial or refined human factors requirements and issues for the alternative solutions, the HFC identifies the human factors criteria that may be used to help

select a preferred alternative. The HFC begins to identify the human factors criteria, measures, thresholds, and data needed to assess the issues and alternatives from a human performance and human resource perspective. These criteria include quantitative and qualitative information about the operation and maintenance of the alternative solutions. Criteria relevant to the solution selection include human factors components of cost, benefits, schedule, and performance parameters:

- **Cost and benefit criteria** may include funding for research, acquisition, and life-cycle support related to manpower levels; cost or savings related to type and skill of required personnel; training costs or savings; and equipment costs or savings necessary to achieve the appropriate level of human-system performance.
- **Schedule criteria** may include the amount of estimated time necessary to identify and resolve human factors issues or the amount of risk associated with resolving human factors issues.
- **Performance criteria** may include human-system measures of effectiveness, human-system measures of suitability, workload, usability, personnel and staffing requirements, and considerations of performance payoffs from training. Measures of these criteria may address the

nature of operator tasks involved, accuracy and error rates, training time, CHI complexity, design guideline compliance, or other measures.

Market Analysis Participation: The HFC participation in the market analysis provides support for the assessment of candidate solutions from the human-system performance and ergonomic perspective. The HFC provides a list of issues that should be explored and information that should be collected during the conduct of the market analysis. These issues and information requirements will be derived from the issue identification step discussed above. Issues to be addressed during market analysis may include:

- special skills and training required
- special tools and software required
- complexity of system hardware and software designs
- human-system performance demonstrations, testing results, or guarantees
- operator and maintenance performance records on fielded systems.

Alternatives Analysis: Using the IA Team's selection criteria (e.g., constraints, limitations, costs, benefits, risks), the HFC provides human factors input to the analysis of the alternatives from a human factors perspective. The results of

the HFC's analysis may be documented in a Human Factors Assessment (HFA) for the IA. The IA Team compiles a comparative assessment of the alternatives (from the human factors perspective) that will enable the program to establish the importance of the human factors criteria relative to other solution characteristics or functional assessments (e.g., use terms such as current dollars, system throughput, or program schedule impacts).

Assessing the Human Factors Impact: For all alternatives identified (using the criteria developed, the market survey results, and subsequent analyses), determine the human factors implications of each alternative (in absolute terms or in terms that are relative to the other alternatives). That is, determine the sensitivity of the alternative solution to the range of human factors implications and concerns in view of the alternative's complexity, human-system interface, technology reach for operators and maintainers, and schedule. In order to assess the total human factors impact, it may be necessary to determine the impact on each controller/maintainer, each site, or each component of the system. The conclusion about the HF impact may be summarized such as in Table 5-1, Summary of Human Factors Alternative Analysis for Cost, Benefit, Schedule, and Performance.

Human Factors Areas & Issues	Evaluation of Alternatives (Impact)			
	Alt. #1	Alt. #2	Alt. #3	Alt. #4
• Usability • Human-System Performance • Training • CHI Design • Staffing levels & organizational structures • User skills, abilities & characteristics • Safety & health hazards	C /B /S /P *	C /B /S /P *	C /B /S /P *	C /B /S /P *

* C/B/S/P = Describe the impact on (or the sensitivity of) Cost, Benefit, Schedule, Performance to human factors issues.

Figure 5-1: Summary of Human Factors Alternative Analysis for Cost, Benefit, Schedule, and Performance.

CHECKLIST QUESTIONS

- Has responsibility been clearly designated for the collection of human factors information and for the conduct of human factors supporting activities?
- Has early human factors participation in Requirements and Investment Analysis Teams been organized (especially for plans and schedules of support activities)?
- Have human factors requirements been adequately developed?
- Have human factors information requirements been identified for data collection during market analysis?

- Has the HFC identified each alternative's human factors approach for the various types of acquisition and system solutions?

- Has the HFC established a list of the human factors issues that potentially have an effect on the performance of the system?

- Has the HFC identified the human factors criteria to be used to help select a preferred alternative?

- Has the HFC provided human factors input to the analysis of the alternatives (for cost, benefits, and risks) and documented the analysis in a Human Factors Assessment (HFA) for the IA.

- Have the human factors implications of each alternative been determined for their impact on cost, benefits, schedule, and technical risks?

- Do cost, schedule, and performance baselines reflect the detail necessary to cause the identification or resolution of human-system performance issues/risks?

- Do cost, schedule, and performance baselines in the Acquisition Program Baseline reflect the opportunity to address human-system performance issues/risks?

- Does the Acquisition Strategy Paper reflect the recommended approach to manage the human factors program?

- Has the information from the human factors assessment been incorporated in the Investment Analysis Report and IA decision?

Chapter 6 Formulate Human Factors in System Specifications

PURPOSE

This chapter focuses on incorporating human performance in the system specifications. For human performance to effectively influence the system design, system specifications must accommodate the following essential ingredients for all users:

- Staffing constraints
- System operator and maintainer (user) skills
- Training time available and cost limitations for formal, informal, and on-the-job skill development
- Acceptable levels of human and system performance when operated and maintained by members of the target population

Figure 6-1 describes the process of integrating human factors in the specifications of the system to be acquired.

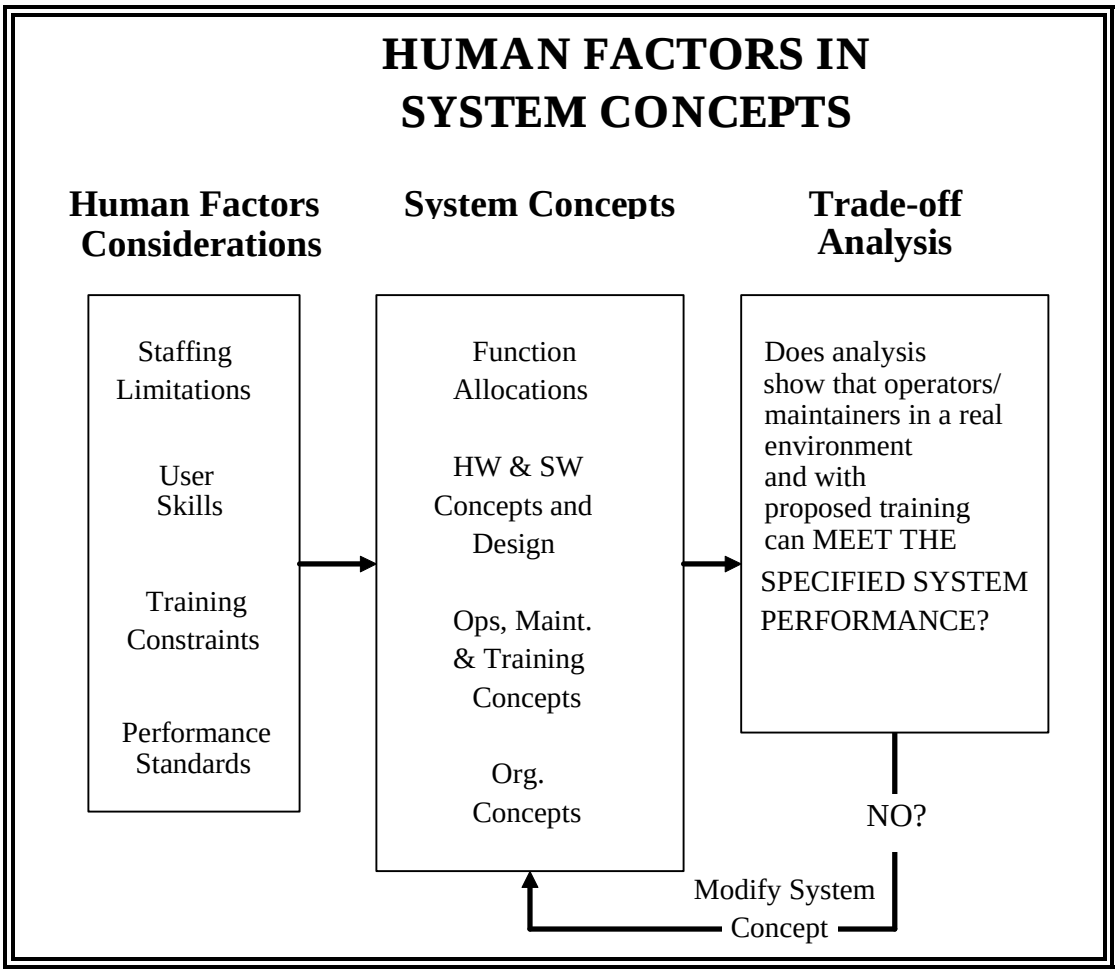

Figure 6-1. Process for incorporating human factors in system concepts.

By identifying and defining human resource and human performance considerations, inputs are provided to the development of system concepts for functional allocation, hardware and software, operations and training, and organizational structure. Through the process of assessing these concepts and the related human resource and human performance trade-offs of various

alternatives, the system concepts (e.g., for requirements, design, and implementation) iteratively evolve. This process applies equally to developmental and to NDI or COTS acquisitions.

The purpose of this process is to place these essential ingredients into the system specifications so that human performance capabilities and limitations will be incorporated in the system acquisition in a contractually binding manner.

TIMING

Human-system performance considerations are embedded into the system by incorporating human factors requirements in system specifications. The formulation of draft human performance requirements is initiated during the Investment Analysis phase and continues through Solution Implementation.

SYSTEM SPECIFICATIONS

From a human performance perspective, the system specification will have the most significant impact on system design. It states the technical and mission performance requirements for a system as an entity, allocates requirements to functional areas, documents design constraints, and defines the interfaces between or among the functional areas.

"HOW TO"

To achieve the design objective in a manner that results in a safe, efficient, usable system for the lowest possible expenditure of resources, the human performance constraints and requirements

need to be placed into the system specification in Sections 2, 3, and 4 of the specification.

Step 1: Provide Human Factors Inputs to Specification Section 3 - *Requirements*

Many of the human performance constraints and requirements will have already been identified. Results of investment analysis and available acquisition documentation such as the Requirements Document, Acquisition Program Baseline, and Integrated Program Plan should be reviewed to identify the functions and performance requirements that include a human component of the new system. The Integrated Product Team translates requirements into a system specification that will drive vendor selection and development in subsequent acquisition phases.

Section 3 provides the heart of the specification and contains the essential requirements and descriptions that apply to the performance, design, and personnel subsystem impacts of the system. It indicates the minimum requirements that the system must meet to be acceptable.

Human factors inputs to this section should address the following issues:

- Performance characteristics - Ensure that all operator and maintainer critical functions and tasks have been identified. Specify operator and maintainer performance standards and criteria to be used in assessing system performance.

- Physical characteristics - Specify such requirements as weight, size, portability, work space and environment, and access provisions.

- User interface - Specify criteria for display design and command language in clear and testable terms. Interface requirements should be based upon documentation and lessons learned.

- Human factors engineering - Specify human factors engineering tasks and activities for the system and include applicable documents by reference. Specify constraints on allocation of functions to people. Include those areas that address high risks, critical tasks, and priority issues. Specify hardware and software to be designed in accordance with accepted human factors engineering practices.

- Safety - Address health and safety issues to minimize the risk to operators and maintainers of mechanical, chemical, radiological, electrical, or environmental hazards.

- Staffing and training - Identify constraints, limitations, and unique or specialized staffing levels, training requirements, and user skill requirements.

Step 2: Provide Human Factors Inputs to Specification Section 4 - *Quality Assurance Provisions*

This section contains the analyses, inspections, demonstrations, tests, and evaluations that the contractor is required to conduct and document to show that the requirements stated in Section 3 have been met.

Human factors inputs to this section should focus on human performance testing and data collection to ensure that the achieved level of human performance will meet system performance objectives and requirements. The goal is to be able to measure operator and maintainer performance of specified critical tasks in terms of time and accuracy and not merely rely on observations. Measures of performance may need to be specified.

A traceability matrix should be prepared to ensure that the human factors requirements stated in Section 3 are tested for compliance, and that all human performance testing that is conducted is traced back to a requirement.

The requisite skills and training levels of the user should be specified and verified. In addition to collecting system performance data on functions and tasks, the contractor may be required to conduct interviews or administer surveys to operators and maintainers and relate their responses to their measured performance.

Step 3: Provide Human

Section 2 is a listing of those documents that have been referenced in other sections of the

Factors Inputs to Specification Section 2 - *Applicable Documents*

specification. Any document that is mentioned in the specification should be listed in Section 2. Similarly, any document that is listed in Section 2 should be mentioned in another part of the specification.

CHECKLIST QUESTIONS

- Has the Human Factors Working Group had the opportunity to review and comment on the system specification?
- Have potential operators, maintainers, and support personnel been identified?
- Have human performance requirements been identified?
- Have human capabilities and limitations been considered in developing total system performance requirements?
- Have human performance characteristics, physical characteristics, human engineering, safety, staffing and training requirements been specified?
- Has human performance data collection and testing been identified to verify compliance with human factors requirements?
- Have measures of performance been identified to quantify human performance?
- Have human factors documents referenced in the specification been included in the Applicable Documents section?

Chapter 7 Generate Human Factors Input to the Statement of Work

PURPOSE

This chapter describes the process to generate human factors requirements in Statements of Work (SOWs), which include contract data requirements lists (CDRLs) and data item descriptions (DIDs) for FAA system acquisitions. This chapter includes a listing of typical human factors-related DIDs.

In simple terms, the SOW states the work the Government wants the contractor to perform, the CDRL specifies the data to be provided to the Government for a specific contract, and the DID specifies the format and content of the data to be submitted to the Government.

The objective of the human factors effort is to integrate all elements of the system involving human performance and safety, and to influence system design so as to optimize total system effectiveness. The objective of this human factors task is to translate these human performance design and integration activities to the contractor as clear, unambiguous requirements in a contractually binding way. Human factors

contractual requirements, through the SOW, CDRLs, and DIDs, are the critical elements to achieve design and development conformance.

TIMING

Human factors requirements should be included in all appropriate SOWs and contracts during the development of concepts and alternatives, the development of prototypes and first items, low-rate initial production, and full production.

"HOW TO"

HUMAN FACTORS IN STATEMENTS OF WORK

A good SOW starts with an understanding of what the Government wants the contractor to do. The starting point for determining human factors requirements for inclusion in the SOW is a review of human factors requirements in the Requirements Document, Acquisition Program Baseline, and the Integrated Program Plan to identify human factors issues that must be resolved, and tasks and analyses that must be conducted by the contractor to ensure that human performance goals are met.

Essential human factors elements that must be addressed by the requirements in the SOW include:

- Limits to the skill level and characteristics of operator, maintainer, and support personnel
- Maximum acceptable training burden
- Minimum acceptable performance of critical tasks
- Acceptable staffing limits

- Elimination or control of system safety and health hazards.

The contractor's response to these requirements will result in a comprehensive human factors program for the system that defines the management and technical aspects of the effort. The response should also address the scheduling of key events and their timing in relation to other system engineering activities.

The contractor's human factors effort also should be coordinated with system engineering, quality assurance, integrated logistic support, and test and evaluation activities to achieve an integrated overall effort without duplication.

An adequately staffed human factors effort must be an integral part of the hardware and software analysis, design, development, and test process. The contractor's human factors effort must be planned and executed to meet the objectives, characteristics and constraints set forth in the Statement of Work and in the System Specification. The contractor's program must demonstrate how it effectively integrates human factors with their design and development process.

The scope and level of effort to be applied to the various human factors tasks and activities must be tailored to suit the type of system being acquired, the acquisition strategy, and the acquisition phase.

The SOW should describe the specific task or activity required and the associated data deliverable. Human factors reviews and demonstrations should be planned and conducted to coordinate and verify that human performance requirements are being met. The contractor should convincingly indicate how human performance data influences system lifecycle design and support.

Human factors inputs are generally made to the following sections of the SOW.

- Section 1 - Scope
- Section 2 - Applicable Documents
- Section 3 - Requirements
- Section 4 - Quality Assurance Provisions

Step 1: Provide Human Factors Inputs to SOW Section 1 - *Scope*

This section provides a brief statement of what the SOW does and does not cover.

Background information may be given but should be limited to what is needed to acquaint the offeror with the basic acquisition requirement. In view of the fact that human performance is a key component of total system performance, it is also appropriate to include a short description on human-system interfaces.

Step 2:

The specific work to be performed under the

Provide Human Factors Inputs to SOW Section 3 - *Requirements*

contract is given in Section 3 of the SOW. The tasks must be written so that the Government and the offeror can estimate the probable cost and schedule of accomplishing the work. The offeror will need to be able to estimate the necessary expertise, labor, and other resources required of the tasks. The requirements need to be written such that there is a clear understanding of the tasks and there is no question of an obligation to perform. Only minimum performance requirements and capabilities should be cited. Desired capabilities should be clearly identified as such. General information should be separated from directions to the contractor. This is to help ensure that background information and suggested procedures are clearly distinguishable from contractor responsibilities.

Human factors objectives to consider in developing requirements are:

- Human engineering - Develop or improve the human-system interface; achieve required level of human performance during system operation and maintenance; and make economical demands upon human resources, skills, and training.
- Staffing and personnel - Estimate and evaluate the staffing implications of alternative system concepts in terms of total numbers of personnel required, job classification, skill levels, and experience required. Additionally, conduct

evaluations and trade-offs between design, operations, and training.

- Training - Identify critical and "high driver" tasks and develop the training courses, devices and aids that will enhance the human performance of mental and physical human-system interfaces within the training constraints identified. Determine optimum solutions for attaining and maintaining the required proficiency of operating, maintaining, and support staff.
- System safety and health hazards - Define and address the potential for harm or injury to operators, maintainers, and customers induced by hardware and software design. Provide methods for elimination or control of these deficiencies. Identify inherent, expected, and potential hazards based on the system concept and eliminate, preclude, or alleviate these hazards to a tolerable level.

Chapter 4 provides sample requirements that could be considered for inclusion in a SOW. The Human Factors Coordinator should add to, delete from, or modify this sample listing such that the human factors requirements are consistent with the nature of the system being acquired.

Step 3: This section contains the analyses, inspections,

Provide Human Factors Inputs to SOW Section 4 - *Quality Assurance Provisions*

demonstrations, tests, and evaluations that the contractor is required to conduct and document to show that the requirements stated in Section 3 of the SOW have been met.

Human factors inputs to this section should focus on human performance testing and data collection to ensure that the achieved level of human performance will meet system performance objectives and requirements. The goal is to be able to measure operator and maintainer performance of specified critical tasks in terms of time and accuracy and not merely rely on observations. Measures of performance and measures of effectiveness may need to be specified.

A traceability matrix should be prepared to ensure that the human factors requirements stated in Section 3 are tested for compliance, and that all human performance testing that is conducted is traced back to a requirement.

The requisite skills and training levels of the test participant should be specified and verified. The contractor may be required to conduct interviews or administer surveys or questionnaires to operators and maintainers and relate their responses to their measured performance.

Step 4:

Section 2 is a listing of those documents that have

Provide Human Factors Inputs to SOW Section 2 - *Applicable Documents*

been referenced in other sections of the SOW. Any document that is cited in the SOW should be listed in Section 2. Similarly, any document that is listed in Section 2 should be cited in another part of the SOW.

HUMAN FACTORS IN CONTRACT DATA REQUIREMENTS LISTS

The purpose of the CDRL is to describe the items that are required to be delivered under the terms of the contract. The CDRL identifies for the offeror what reports, analyses, and other data the contractor is required to submit concerning tasks specified in the SOW. The CDRL provides information regarding the time frame for initial and subsequent submissions, the number of copies required, the distribution, and whether the Government will approve the document. If required data are not listed on the CDRL, the contractor is not obligated to provide it to the Government. However, the contractor is still obligated to do the work and make the data available for review by the Government.

The Human Factors Coordinator should review the CDRL to ensure the proper timing of submission of the data and that the appropriate distribution is indicated. The Human Factors Coordinator also should recommend approval or rejection of the delivered product for those items requiring Government approval.

HUMAN FACTORS IN DATA ITEM DESCRIPTIONS

A DID describes the format and content of the data that is to be provided to the Government as required by the SOW and CRDL. While not the only means of transmitting this information to the contractor, a DID is used to standardize the format and content for a given data item. This ensures consistency across contracts and between contractors.

For data to be produced and delivered, the description of the work effort necessary to produce the data must be in the SOW; the description, definitions, format and content of the data product must be provided on a DID; and the DID must be listed on the CDRL to provide delivery and other instructions.

A listing of representative human factors-related DIDs is provided in Table 7-1. Each DID listed on the CDRL is a separate item. The DID should be tailored to require only those items that are pertinent to the system being acquired, and what is necessary to allow the human factors engineer sufficient information to assess the quality and suitability of the contractor's human factors effort. DIDs can only be tailored downward; items cannot be added.

The Human Factors Coordinator should prepare a list of human factors-related DIDs applicable to the system being acquired and provide them for inclusion in the SOW.

TABLE 7-1. HUMAN FACTORS-RELATED DIDS

HUMAN ENGINEERING	
FAA-HF-001	Human Engineering Program Plan
FAA-HF-002	Human Engineering Design Approach Document - Operator
FAA-HF-003	Human Engineering Design Approach Document - Maintainer
FAA-HF-004	Critical Task Analysis Report
FAA-HF-005	Human Engineering Simulation Concept
MANPOWER, PERSONNEL, AND TRAINING	
FAA-STD-028 DID-1	Personnel Qualification Report
FAA-STD-028 DID-2	Task and Skills Analysis Report
FAA-STD-028 DID-3	Cognitive Task Analysis Report
FAA-STD-028 DID-4	Commercial Off-The-Shelf Training Materials Report
FAA-STD-028 DID-5	Training Development Plan
SYSTEM SAFETY/HEALTH HAZARDS	
FAA-DI-SAFT-101	Preliminary Hazard Analysis
FAA-DI-SAFT-102	System Safety Program Plan
FAA-DI-SAFT-103	Sub-System Hazard Analysis
FAA-DI-SAFT-104	System Hazard Analysis
FAA-DI-SAFT-105	Operating & Support Hazard Analysis
FAA-DI-SAFT-106	Health Hazard Assessment
FAA-DI-SAFT-107	System Safety Assessment Report
FAA-DI-SAFT-108	Safety Requirements Verification Table

CHECKLIST

- Are the human factors requirements consistent

QUESTIONS	
	with the nature, complexity, and degree of human involvement of the program?
Statement Of Work (SOW)	• Do the human factors requirements cite the appropriate specifications or standards? • Have all human factors-related tasks and analyses to be performed by the contractor been identified in the SOW?
Contract Data Requirements List (CDRL)	• Has a human factor data requirement been prepared for each human factor deliverable cited in the SOW? • Are the human factors-related organizations included on the distribution for the delivered product? • Have the human factors data requirements been coordinated with other disciplines to eliminate redundancy of data deliverables? • Is the Human Factors Coordinator responsible for participating in the approval or rejection of the delivered product?
Data Item Description (DID)	• Has the DID been tailored (downward only) to include only the information that is necessary? • Are the data item requirements consistent with the nature and complexity of the program?

Chapter 8 Specify Human Factors in Source Selections

PURPOSE

This chapter explains the functions of the human factors professional in source selection. These functions include assisting in preparation of the proposal evaluation criteria and Source Selection Plan and participating as a member of the source selection team.

TIMING

Human factors criteria must be developed to support source selections conducted in any acquisition phase. In many instances, source selections are only conducted during Solution Implementation and In-Service Management phases.

"HOW TO"

Since it is difficult to enforce compliance after a contract is awarded if vendor capabilities are inadequate, offerors must demonstrate the ability to incorporate human factors design criteria and guidelines into their system design and engineering before contract award. The Government first plans the approach and then includes human factors requirements in the Screening Information Request (SIR), which includes the proposal evaluation

criteria. Offerors show they understand the requirements by making human factors commitments in their proposals. The offerors must demonstrate comprehension of and the ability to comply with the total system performance concept as well as their ability to integrate human considerations into system design and development. The human factors practitioner, having provided input to the source selection plan, helps determine how well offerors have met the human factors selection criteria.

Step 1: Provide Input to the Screening Information Request

The Integrated Product Team (IPT) Human Factors Coordinator assists in developing the documentation the offeror must submit and the proposal evaluation criteria. The criteria must define the quantity and quality of the effort required. The human factors portion of the criteria should contain two primary requirements.

1. Require offerors to define how they will organize and manage their human factors program for the system.

2. Require offerors to describe how they will execute the technical human factors program and integrate human factors throughout their design and engineering efforts.

For nondevelopmental items (NDI) or commercial-off-the-shelf (COTS) procurements, the hardware

and/or software has already been developed, so the criteria will focus on the existing product as opposed to a product to be developed. Human factors criteria must still be met.

The SIR (usually in Section L) describes the information an offeror must provide to the Government against which the proposal will be evaluated.

Section M of the SIR provides the basis for award, the evaluation order of importance, and the evaluation criteria. The human factors criteria to be included in Section M can be stated as a separate criterion or be embedded with other criteria such as system engineering, technical, or functional suitability.

Table 8-1 lists some potential human factors inputs to the proposal evaluation criteria.

Step 2: Provide Input to the Source Selection Plan

After human factors criteria have been developed and are included in the proposal evaluation criteria portion of the SIR (Section M), the IPT Human Factors Coordinator should help develop the Source Selection Plan.

The weight human factors will have in rating and ranking the proposals must be determined. This will vary greatly from system to system with the greatest influence being the degree of human

involvement as part of the total system. The total weight is 100% and there are legitimate competing interests for priority. If human factors is considered a separate criterion, it is assigned a weight, as are other criteria such as technical and cost (Figure 8-1.). If human factors criteria are embedded within other criteria, it is assigned a weight as a sub-element of the main criterion (criteria).

Regardless of the approach taken, the human factors criteria must be visible and given sufficient weight, consistent with the nature of the program including the degree of human involvement, performance risks, consequence of error, and the like.

Finally, the human factors practitioner determines how each human factors criterion will be evaluated. The scoring will normally be based on quantitative and qualitative factors. The following figure demonstrates a conceptual breakout of human factors elements in a Source Selection Plan where human factors is a separate criterion.

Step 3: Participate on the Source Selection Team

Representation of human factors expertise on source selection team or panel(s) will provide the capability to adequately assess the human factors aspects of proposals. The human factors representative must be technically qualified in human factors and adequately trained in the source selection process.

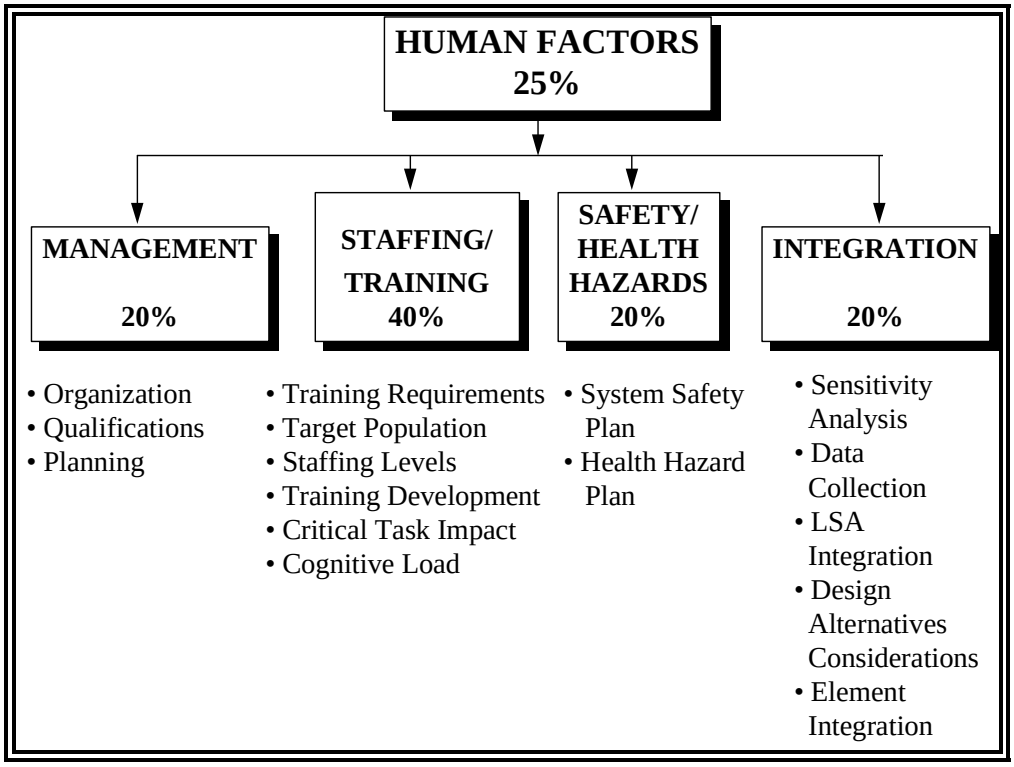

Figure 8-1. Sample weighting of human factors criteria.

Minimal qualifications and training for the team representative include knowledge of:

- The overall system and its intended purpose in the field.
- The human interface required to achieve optimum system performance.
- The human performance concerns and issues applicable to the system.
- The requirements, specifications, special instructions, deliverables, and evaluation criteria as set forth in the SIR as well as what

evidence is sufficient to demonstrate compliance with the criteria.

- The procedures for rating and ranking the proposals.

CHECKLIST QUESTIONS

Evaluation Criteria

- Have human performance criteria or standards been identified for the system and quantified in the SIR?
- Does human factors (as a separate criterion or as embedded criteria in other primary factors) adequately represent the user performance, risks, complexity, consequence, and exposure?
- Are offerors required to develop a human factors program management plan?
- Are offerors required to demonstrate technical competence in human factors?

Source Selection Plan

- Have human factors criteria been adequately and clearly identified in the source selection plan?
- Are human factors criteria adequately weighted for this system (considering degree of human interface with hardware and/or software)?

Source Selection Teams

- Is there a human factors member on the source selection team or supporting panel(s)?
- Is the human factors member technically qualified to evaluate human factors aspects of the proposals?

- Where human factors criteria are embedded with other criteria, is human factors represented in those other criteria evaluations?
- Is the source selection team adequately appraised on the evidence necessary to demonstrate vendor capability and compliance?

TABLE 8-1

POTENTIAL HUMAN FACTORS INPUTS TO THE PROPOSAL EVALUATION CRITERIA

Management Planning	• Adequacy of offeror's human factors organization, level of effort, lines of authority, visibility to top management, and potential impact on design decisions. • Adequacy of offeror's concept for contributing to and helping to execute the human factors program.
Execution	• Coordination of human factors activities with the total management system and work breakdown structure. • Coherence of offeror's plan for tracking and reporting human factors task performance and for assuring quality.
Technical Qualifications	• Quality of offeror's and subcontractor's previous experience in human factors-related tasks.

	• Capability of offeror's personnel, including key subcontractor personnel, to perform required human factors tasks.
Evaluation	• Adequacy of offeror's methodology for validating human factors requirements as part of the test and evaluation requirements identified in SIR. • Adequacy of test and evaluation facilities to perform human factors assessments and analyses.
Human Factors Understanding	• Offeror understands human factors concepts as a means for enhancing total system performance. • Adequacy of offeror's concept for assuring that the system design will reflect human factors goals and constraints.
Training	• Indicates how the training developer will serve as a resource for design ideas and for assessing the training impact on design. • Understanding of the impact of design on training devices and other aids. • Recognizes the impact of skill decay on sustainment training and demonstrates capability for reducing skill decay through cost-effective changes in the design. • Recognizes the influence of human aptitude on success in training and consequently, on system performance.

	• Recognizes the value of positive transfer of current skills on new training.
Human Engineering	• Staffing level and quality of offeror's human factors engineers, including subcontractors, available for this system. • Adequacy of plan for functional and/or task analysis and critical task identification to determine appropriate task burden on humans. • Shows approach for tracking the functions, information flow, and processing steps that the operator must monitor. • Adequacy of plans for estimating physical and cognitive workloads of operators and maintainers, by group and individually, with reference to staffing and training constraints. • Adequacy of approach for allocating functions to the human, hardware, or software for optimum system performance. • Addresses the design of the work environment, including space claims and other workstation variables, as the work environment influences system performance. • Ensures that human engineering data collection, testing, and evaluation plans use appropriate and valid equipment and techniques such as mockups, simulations, models, and prototypes.

	• Adequacy of plans to conduct failure analysis and documentation of redesigns made in response to human-system performance problems and failures.
Staffing	• Adequacy of approach to reduce staffing needs while maintaining desired system performance. • Adequacy of plans for analyzing trade-offs among design options that could produce lifecycle personnel savings and costs, informing the Government of results and making appropriate design changes. • Addresses the impact of varying staffing levels on total system performance.
Human Resource Skills	• Demonstrates an understanding of the projected operators and maintainers and the human factors goals and constraints that are imposed by that target population. • Ability to recognize the use of skill specialties that present staffing difficulties or are low in density and would be difficult to expand quickly. • Adequacy of plans for identifying the human resource-intensive aspects of the system and explaining how alternative designs will be pursued. • Adequacy of plans to identify and clarify personnel workload issues during design work. • Addresses the impact of varying skill and experience levels on total system performance. • Identifies skills that are critical to successful mission

	performance and explains how these skills relate to the capabilities of the operators, maintainers, and supporters.
System Safety and Health Hazards	• Adequacy of plans to identify potential safety hazards in all environments over system lifecycle and documentation of acceptable residual risks. • Estimates severity, frequency, and scope of exposure of risks, incidents, and accidents. • Demonstrates a plan for tracking changes in design and for continuously evaluating safety impacts. • Adequacy of plans to establish pre-defined levels of acceptable risk and estimates the influence of these risks on operator and maintainer performance. • Demonstrates an understanding of health hazards, including secondary impacts on staffing decisions. • Adequacy of plans to identify psychological influences on human performance that can be controlled favorably through system design. • Evaluates hazards in the intended operating environments and determines priorities for control through initial design and retrofit. • Identifies alternative technical concepts to control, reduce, or avoid health hazard risks. • Demonstrates ability to prepare test and evaluation plans using state-of-the-art practices, criteria, standards, and lessons learned data bases.

Systems Integration	• Assures integration of human and machine within a system (for example, engineering decisions should be made with continual reference to human performance and system functions should be matched to human attributes during task allocation). • Adequacy of plans to coordinate and efficiently conduct the collection, analysis and interpretation of human performance data. • Assures that performance of the system is consistent with the performance and goals of larger enclosing systems. • Shows that trade-off and sensitivity analyses are used to evaluate design alternatives with appropriate emphasis on human impacts. • Presents valid human performance tests of the system in realistic and anticipated environments and combinations of environments. • Shows that system design and human factors analysis will be performed, so that problems are fed back and eliminated early in the design phase.
Operations and Support Cost Evaluation	• Adequacy of offeror's analysis of system costs and projections in relation to human factors topics. • Adequacy of offeror's cost trade-off analysis in meeting human factors-related requirements.

Chapter 9 Integrate Human Factors in System Engineering

PURPOSE

This chapter describes the human factors engineer's role in system engineering. System engineering is the translation of operational requirements into design, development, and implementation concepts, requirements, and specifications. The Human Factors Coordinator assists the Government's and contractor's system engineering effort by integrating human factors within the acquisition process. Identifying the human performance boundaries, risks, trade-offs, and opportunities of the system engineering options and alternatives does this.

Human factors engineering is applied during design, development, and implementation of systems, software, and facilities to effectively integrate human resource and performance considerations. A human factors engineering effort is conducted to:

- Develop or improve human interfaces of the system,
- Achieve required effectiveness of human performance during system operation, maintenance, and support, and

- Make economical demands upon personnel resources, skills, training, and costs.

TIMING

Human factors in the system engineering process is initiated in the Investment Analysis phase of the acquisition process and continues through Solution Implementation and into In-Service Management.

"HOW TO"

System engineering is an interdisciplinary approach to evolve and verify an integrated and lifecycle-balanced set of system product and process solutions that satisfy customer needs.

The Human Factors Coordinator assists in the system engineering task by contributing information related to design enhancements, safety features, automation impacts, human-system performance trade-offs, ease of use, and workload. The Human Factors Coordinator also assists in identifying potential task overloading or skill creep for system operators and maintainers. Where user teams or operator juries and representatives participate in achieving an operational viewpoint to design, the IPT human factors engineer complements the effort to ensure performance data represents more than individual preferences. Optimally, the Human Factors Coordinator participates fully in system engineering design decisions.

While the actual design and development work may be completed by either the government or the contractor, the IPT Human Factors Coordinator (in conjunction with the human factors user group) provides close, continuous direction throughout the acquisition process. To accomplish this, the Human Factors Coordinator reviews all documentation for human performance impacts that will affect total system performance and exercise his or her responsibility by participating in technical meetings and system engineering design reviews.

The human factors engineering effort includes those system engineering tasks and activities listed in Table 9-1. The human engineer actively participates in four major interrelated areas of system engineering:

- Planning
- Analysis
- Design and Development
- Test and Evaluation

Step 1: Human Factors Engineering in Planning

Human factors engineering planning is performed to ensure effective and efficient support of the system engineering effort for human performance and human resource considerations. Human factors engineering program planning includes the human factors

tasks to be performed, human factors engineering milestones, level of effort, methods to be used, design concepts to be utilized, and the test and evaluation program, in terms of an integrated effort within the total project.

Table 9-1. Human Factors-Related Tasks and Activities

- Prepare operationally realistic mission profiles and mission scenarios.
- Prepare functional flow block diagrams for the system.
- Perform a functional analysis of each flow block and define operational and support equipment and facilities requirements.
- Prepare system and subsystem schematic block diagrams.
- Study detailed functions, environment and technical design requirements to allocate tasks to personnel, equipment, software, or some combination thereof.
- Prepare operation and maintenance timeline analyses to determine system reaction time.
- Prepare and analyze operations and maintenance workload and task data to influence equipment and procedure design, and to determine personnel requirements.
- Identify training implications.
- Conduct trade studies.
- Participate in preparation of specifications for the system.
- Participate in design reviews, demonstrations, and test and evaluation activities.

The human factors engineering planning effort specifies the documentation requirements and assists in the coordination with other program activities. Government and contractor documentation provides traceability from initially identifying human factors engineering requirements during analysis and/or system engineering, through implementing such requirements during design and development, to verifying that these requirements have been met during test and evaluation. The efforts performed to fulfill the human factors engineering requirements must be coordinated with, but not duplicate, efforts performed by other system engineering functions.

Step 2: Human Factors Engineering in System Analysis

To support system analysis, the functions that must be performed by the system in achieving its objective(s) within specified mission environments are analyzed for their human factors implications and alternatives. Human factors engineering principles and criteria are applied to specify human-system performance requirements for system operation, maintenance and support functions and to allocate system functions to automated operation and maintenance, manual operation and maintenance, or some combination thereof. Function allocation is an iterative process to achieve the level of design detail appropriate for the level of system definition.

Functional Analysis. Human factors functional analyses are conducted to determine information flow and processing required by the users to

accomplish the system objective(s) including the decisions and operations to be performed.

Human roles in the system are identified and distinguished from machine functions. Estimates of human (vs. machine) processing capability in terms of workload, accuracy, rate, and time delay are prepared for each potential operator and maintainer information processing function. Comparable estimates of equipment capability are also made. These estimates are used initially in determining allocation of functions and are refined at appropriate times for use in definition of operator and maintainer information requirements.

Functional Allocation. From projected operator and maintainer performance data and known constraints, analyses and trade-off studies are conducted to determine which system functions should be machine-implemented or software controlled and which should be reserved for the human operator and maintainer. Allocation of functions considers the error and delay risks for each design alternative so that designs prevent or minimize the impact of, or sensitivity to, situations where human decisions are made under conditions of uncertainty, time constraints, or workload stress. The potential and opportunities to influence human or equipment capabilities through personnel selection and training as well as through equipment and procedure design are also considered.

Design Configuration. Human factors engineering principles and criteria are applied along with all other design requirements to identify and select the particular equipment to be operated and maintained by personnel. The selected design configuration should reflect human factors engineering inputs to satisfy the functional and technical design requirements and to ensure that the equipment will meet the applicable human factors engineering design criteria.

Task Analysis. Human factors engineering principles and criteria are applied to analyses of tasks and workload. These analyses are provided as basic information for developing preliminary manning levels, equipment procedures, personnel skill requirements, training needs, and communication requirements.

A task analysis is conducted as a basis for making design concept decisions. Time requirements for tasks are evaluated with respect to task duration versus time availability, task sequencing, and task simultaneity. Task requirements are evaluated with respect to accuracy; precision; completeness; and the effects of task feedback, error tolerance, and error recovery on performance. Those tasks identified during human factors engineering analyses that require critical human performance are analyzed in greater detail.

Operator and maintainer workload analyses are performed and compared with performance criteria. To avoid overloading or underloading, the

degree to which demands of any task or group of tasks tax the attention, capacities, and capabilities of system personnel (and thus affect performance) are also evaluated. Sensory, cognitive, and physiological limitations are considered. The workload analyses help determine operational sequences and task times.

Human-system interface design incompatibilities and excessive skill and physical requirements, identified by task or workload analyses, are corrected by changing design or restructuring tasks to preclude degraded human performance.

Step 3: Human Factors Engineering in Detail Design

During detail design, the human factors engineering requirements are converted into detail engineering design features. Design of the equipment should satisfy human-system performance requirements and meet the applicable human factors engineering design criteria. The human factors engineer participates in design reviews and engineering change proposals for those items having a human interface.

Tests and Studies. The Government and contractor conduct experiments, tests, simulation, and studies to resolve human factors engineering problems specific to the system. Experiments, tests, and studies are performed in a controlled environment with representative users in a realistic operating environment in order to validate design goals and system performance objectives.

Drawings and Representations. Human factors engineering principles and criteria are reflected in the engineering drawings and computer-aided design representations to ensure that the final product can be effectively, efficiently, reliably, and safely used and maintained. Design, as reflected in such drawings, should comply with applicable human factors engineering criteria. The human factors engineer reviews all layouts and drawings having potential impact on human performance or interface and identifies for corrective action those designs which may induce human error, excessive delay, or be unsafe.

Environmental Conditions. Human factors engineering principles and criteria are applied to detail design of work environments to be used by system personnel. Design of work environments which affect human performance, under normal, unusual, and emergency conditions, should consider the following:

- Acoustic noise and vibration.
- Adequate space for personnel, their movement, and their equipment.
- Adequate physical, visual, and auditory interface between personnel and their equipment including eye positions in relation to display surfaces, controls, and other visual areas.
- Safe and efficient walkways, stairways, platforms, and inclines.
- Provisions to minimize physiological stresses.

- Provisions to minimize physical fatigue.
- Equipment handling provisions and tools.
- Safe and error-proof equipment installations.
- Protection from chemical, biological, toxicological, radiological, thermal, mechanical, electrical, and electromagnetic hazards.
- Optimum illumination commensurate with anticipated visual tasks.

Procedures. Based upon the human performance functions and tasks identified by human factors engineering analyses, the human engineer applies the necessary principles and criteria to the development of procedures for operating and maintaining the system. This effort ensures that the human functions and tasks are organized and sequenced for efficiency, safety, and reliability.

Software. The human engineer applies the appropriate principles to the software design in those systems where software determines part of the human interface. Software that affects controls and displays is evaluated for the impact on the human-system interface. Automated system functions requiring human monitoring or intervention are considered as part of the human-system interface. Multifunction controls and displays that vary in function are also part of the human-system interface.

Technical Documentation. Human factors engineering is applied to the development of manuals, including illustrations, to ensure thoroughness, technical accuracy, suitable format of information presentation, appropriate reading level, technical sophistication required, and clarity.

Step 4: Human Factors Engineering in Test and Evaluation

The Government and contractor establish and conduct a test and evaluation program that addresses human factors to:

- Ensure fulfillment of the applicable human performance requirements;
- Demonstrate conformance of system, equipment, and facility design to human factors engineering design criteria;
- Confirm compliance with system performance requirements where human performance is a system performance determinant;
- Secure quantitative measures of system performance which are a function of the human interaction with equipment; and
- Determine whether undesirable design or procedural features have been introduced.

The fact that the above may occur at various stages in system development should not preclude a final human factors engineering verification of the complete system.

Human factors engineering testing is incorporated into the system test and evaluation program and is integrated into engineering design and

development tests, demonstrations, acceptance tests, fielding and other implementation assessments. Compliance with human factors engineering requirements should be tested as early as possible. Human factors engineering findings from design reviews, mockup inspections, demonstrations, and other early engineering tests should be used in planning and conducting later tests. Human factors engineering test planning is directed toward verifying that the system can be operated, maintained, and supported by user personnel in its intended operational environment.

Human factors engineering test planning should also consider data needed or to be provided by operational test and evaluation. Test planning includes methods of testing (e.g., use of checklists, data sheets, test participant descriptors, questionnaires, operating procedures, and test procedures), schedules, quantitative measures, test criteria and reporting processes.

Human factors engineering portions of tests include:

- Performance of task or mission;
- Critical tasks;
- Representative samples of non-critical, scheduled and unscheduled maintenance tasks;
- Personnel who are representative of the range of the intended user populations;
- Proposed job aids, new equipment training programs; training equipment, and special support equipment;

- Collection of task performance data in actual operational environments;
- Identification of discrepancies between required and obtained task performance; and
- Criteria for acceptable performance.

Unfavorable outcomes occurring during test and evaluation are subjected to a human factors engineering review to differentiate between failures of the equipment alone, failures resulting from human-system incompatibilities and failures due to human error. Human-system incompatibilities and human errors occurring in the performance of critical tasks are analyzed to determine the reason for their occurrence and to propose corrective action(s).

CHECKLIST QUESTIONS

- Has the human factors engineering effort been planned as an integrated portion of the overall system effort?
- Has the human factors engineering effort been coordinated with other system engineering functions?
- Has a functional analysis been conducted to determine information flow and processing required?
- Do program user work groups include appropriate human factors expertise?

- Have the system functions been properly allocated between the hardware, software, and the human?
- Does the design configuration conform to human factors engineering design criteria?
- Have the results of task and workload analyses been used to influence system design?
- Have required human performance tests and studies been identified?
- Does the human engineer review all drawings which have a human interface or impact human performance?
- Does the system design reflect expected environmental conditions?
- Is system software subjected to a human factors engineering review?
- Have human factors engineering testing requirements been incorporated into the system test and evaluation requirements?
- Have unfavorable outcomes during test and evaluation been subjected to a human factors engineering review?

Chapter 10 Determine Human Factors Roles in System Test and Evaluation

PURPOSE

This chapter discusses the determination of human factors testing roles and requirements for the Integrated Product Team (IPT) to ensure that human factors considerations are adequately integrated into the system acquisition test and evaluation (T&E) program.

Testing is performed to assess the operational effectiveness and suitability of the products to meet system requirements. The purpose of human factors in system testing is to produce evidence of the degree to which the total system can be operated and maintained by members of the target population in an operational environment. If the total system exhibits performance deficiencies when operated or maintained by members of the target population, the testing should produce human factors causal information.

TIMING

Human factors planning for test and evaluation (T&E) activities is initiated early in the acquisition process during Investment Analysis. Specific

human factors-related T&E tasks and activities are outlined in the Integrated Human Factors Plan (IHFP) as identified in the Integrated Program Plan and in the system testing documentation. The conduct of the human factors T&E is integrated with the system T&E program which is largely performed during Solution Implementation but should include demonstrations and assessments conducted during system analysis early in the program. Post deployment assessments that include human performance parameters assist in lifecycle planning and continuous improvement.

"HOW TO"

Key principles for addressing human factors requirements in system testing are:

- Coordinate human factors test planning early in the acquisition program.
- Measure human performance of critical tasks during testing in terms of time, accuracy, and operational performance.
- Leverage human factors data collection by integrating efforts with system performance data collection.
- Make recommendations for human factors design and implementation changes and human performance improvements.

Providing human factors in system testing entails an early start and a continuous process. Figure 10-1 illustrates the flow of this process. During the

conduct of a front-end analysis, and in conjunction with developing the Human Factors Program, plans and analyses help identify the system functions. The human factors experts review the system functions and identify the human tasks that may be critical to the performance of those functions.

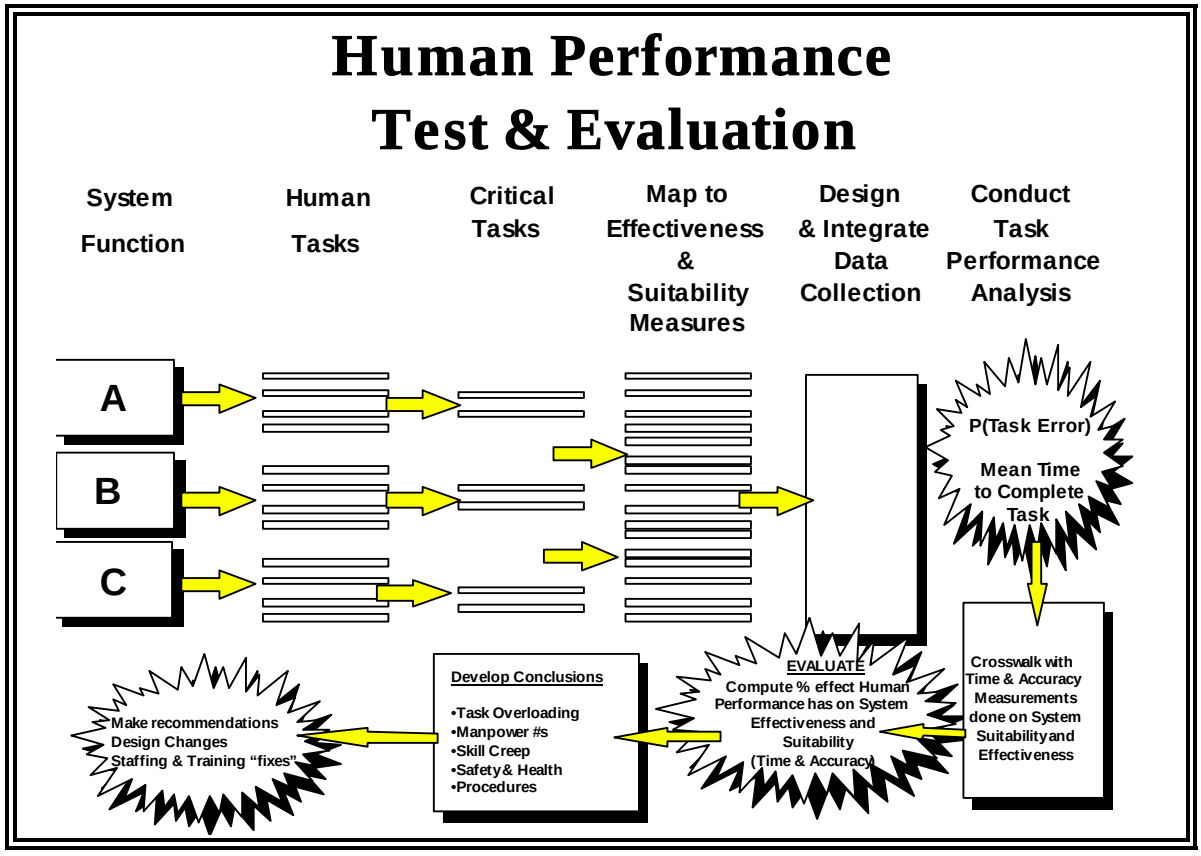

Figure 10-1. Process for providing human factors in system testing.

Simulations, studies, analyses, prototype evaluations, research, and trade-off studies may be required by the human factors experts to determine

the effect of human performance on system performance. Using the system's mission objectives, critical operating issues and related criteria; the human factors experts derive measures of effectiveness, measures of suitability, and the criteria and performance thresholds associated with these measures. Data requirements and data collection plans are formulated along with resources required (e.g., funding, analytical personnel, data collection equipment). Human performance is then tested, analyzed, and evaluated for its impact on system performance.

Since the purpose of incorporating human factors in system acquisition is to produce safer, more effective systems, a continuous feedback loop is established to the other IPT members and the user representative to recommend design and implementation changes and possible staffing and training solutions.

Step 1: Conduct Front-End Analysis

This step consists primarily of applying the results from the front-end analysis conducted during mission analysis and investment analysis to feed the Human Factors Program. Predecessor system(s), similar system components, lessons learned, and other documentation are used to identify critical operational issues, resource limitations and constraints, critical tasks, and operator and maintainer performance levels, as

well as system performance thresholds that should be incorporated into the testing program.

Step 2: Develop Human Factors Testing Requirements

Using the system critical operational issues, human performance operational issues are derived. Based on the results of the front-end analysis, human performance measures of effectiveness (MOE) and measures of performance (MOP) are developed in terms that relate human performance to system performance and operational suitability.

Human factors requirements should identify the data to be collected that is necessary to satisfy the MOEs and MOPs. The data to be collected must be integrated into the system test and evaluation planning and should identify needed support (e.g., personnel and other resources, facilities, software tools, equipment).

Products of this step may include:

- Human factors test planning for inclusion in the system test and evaluation planning
- Issues for resolution by the Human Factors Program
- New or changed procedures for operational test and evaluation
- Operator and maintainer task lists to include identification of critical tasks
- Human performance measures of effectiveness and measures of performance

- Identification of data requirements
- A listing of data collection tools, surveys, questionnaires, analyses, and evaluation schemes
- Resource requirements including equipment, software, data analysis skills, data collection personnel, computer time, personnel training requirements, and the like.

Step 3: Conduct Human Performance Testing

Human factors involvement in early system test and evaluation is critical to producing safe, suitable, and effective systems. Developmental testing, conducted early to reduce risk, often provides useful operational and human factors information. Developmental testing assesses progress toward meeting critical operational issues as well as readiness to proceed to operational testing. Operational test and evaluation, conducted to estimate or verify operational effectiveness and suitability, provides information about human performance as an integral part of system performance.

Data are collected during the developmental and operational tests and the effect of human performance on system performance and operational suitability is calculated or estimated. Inconsistencies between the measures used in the investment analysis and the results obtained from actual test data need to be resolved. Testing and

evaluation should assess the validity of the assumptions and conclusions made during the analysis of various alternatives.

Human performance testing of nondevelopmental or commercial-off-the-shelf items should take advantage of warrantees, previous commercial testing, and product experience. Modeling and simulation are some of the powerful tools used to verify human performance associated with various design approaches.

Step 4: Apply Results of Human Performance Testing

The information developed by the human factors test and evaluation effort provides the other IPT members and the user representative feedback to produce the safest and most effective system possible within program baselines. Recommendations may be made for design or implementation changes or human performance improvements, or training solutions.

CHECKLIST QUESTIONS

- Has a front-end analysis adequately identified the human performance issues for test planning?
- Have human performance critical operational issues and criteria been identified?
- Have human performance Measures of Effectiveness (MOEs) and Measures of Performance (MOPs) been identified?

- Are data requirements identified that will satisfy the MOEs and MOPs?
- Have the resources necessary to support the collection of human performance data been identified and made available?
- Has the human factors data collection effort been integrated with the system data collection effort(s)?
- Have options been identified for human performance data collection if the primary data collection plans are not feasible or practical?
- Are human performance data collected in terms of task performance time and accuracy?
- Are data collectors trained to identify and report potential human performance issues?
- Are other sources of data (such as user comments) being reviewed for human performance issues?
- Have human performance data been analyzed with respect to training effectiveness, task overloading, skill creep, safety, health hazards or procedural inadequacy issues?
- Has feedback been provided to the other IPT members?

Chapter 11 Coordinate with the Integrated Logistics Support Program

PURPOSE

This chapter explains the rationale and steps taken to coordinate the analyses and information content and flow between the Human Factors (HF) and Integrated Logistics Support (ILS) programs.

ILS is a disciplined approach to integrate support considerations into design, to acquire the necessary initial support for the system, and to identify lifecycle support requirements. The Human Factors Program provides the human resource and performance dimension for logistics support requirements and functions. Close coordination between the human factors and ILS programs will reduce data redundancies and result in more effective use of information for both programs.

TIMING

The human factors effort begins during the Investment Analysis phase as does the initial concepts for the ILS effort.

Coordination between the Human Factors Working Group (HFWG) and the ILS teams begins during the Investment Analysis phase and continues throughout the remainder of the acquisition process, as shown in Table 11-1. Each element in the table represents an opportunity for cooperation between the Human Factors and the ILS programs.

"HOW TO"

Coordinating the Human Factors and ILS programs takes active and continuous communication. There are many opportunities to plan requirements, collect data, and share information, especially in the areas of maintenance staffing, training, training support, and personnel skills. Coordination will result in program cost savings or cost avoidance by eliminating redundancy and will strengthen the planning, analysis, design, and testing for both programs during all phases of the acquisition process.

TABLE 11-1
COORDINATION OF ILS & HUMAN FACTORS ACTIVITIES

PHASE	ILS	HUMAN FACTORS
INVESTMENT ANALYSIS	• Form ILS teams • Initiate the ILS program • Conduct early ILS analyses • Prepare ILS Plan	• Form HFWG • Initiate the HF program • Conduct early human factors analyses • Prepare IHFP
SOLUTION IMPLEMENTATION	• Conduct ILS team meetings • Identify contractual requirements • Review data from ILS analyses • Develop ILS documentation	• Conduct HFWG meetings • Identify contractual requirements • Review data from HF analyses • Develop HF documentation
IN-SERVICE MANAGEMENT	• Conduct ILS team meetings • Identify issues from post-fielding assessments • Collect lessons learned	• Conduct HFWG meetings • Identify issues from post-fielding assessments • Collect lessons learned
ALL PHASES	**Coordinate ILS and HF**	

Step 1: Coordinate Joint Participation in Meetings

The Human Factors Coordinator participates in ILS team meetings and the ILS representatives participate in HFWGs. If the participants in the meetings appear to be similar, it may be economical to coordinate meeting times and locations. There are many opportunities for the two groups to share workload as they develop their HF and ILS documentation. Joint participation in meetings allows the participants to address common issues and areas of concern.

Step 2: Coordinate Conduct of Analyses

The ILS and human factors communities offer a rich environment for tools to assist in the analyses to be conducted in support of the acquisition program during its lifecycle. Many are readily available within the FAA acquisition working environment. For guidelines, standards, and tools not already available from the FAA Acquisition System Toolset (FAST), the process of identification should exploit other centers of information and expertise, including the FAA Human Factors Office, Human Systems Information Analysis Center (HSIAC) (HSIAC), National Technical Information Service (NTIS), and Defense Technical Information Center (DTIC).

Some approaches and techniques may be performed in-house with available expertise and facilities while others require non-routine training, specialized equipment, and unique capabilities and facilities.

Subsequent to the identification of analyses and data requirements, comparing the planned tasks and activities for the two programs yields an assessment of the synergy to be achieved between the ILS and human factors efforts. Many analyses and analytical techniques may simultaneously provide results that meet both human factors needs and logistic support analysis (LSA) requirements. Analyses and data requirements that may intersect both programs include such areas as:

- Use Studies: Assessment of the intended use of new equipment identifies the impact of the operational and support environment on the constraints and limitations of the operators and maintainers.
- Comparative Analyses: Baseline comparisons with other systems are established to represent the characteristics of the new system for design and supportability features and to identify high cost human resource and high risk human performance areas.
- Trade-off Analyses: Staffing, training, and human performance implications are evaluated for alternative approaches to design and support.
- Task Analyses: Operations and maintenance tasks are identified and analyzed for human resource and performance considerations.

- Early Fielding Analyses: The impact of the introduction of new equipment is assessed in terms of supportability and suitability.

The results of the human factors and ILS analyses conducted during the acquisition should be shared, and it may be beneficial to create a common data base as well as to collaborate on lessons learned.

Step 3: Coordinate Inputs to Procurement Documents

Joint development of inputs to the Screening Information Request (SIR) (statement of work, specifications, and data to be delivered) benefits the human factors and ILS programs. Coordinated inputs to the SIR will help prevent redundancy and delineate unique requirements for one program not covered by the other. The complementary effort provides full coverage of the needs of system operators, maintainers, and supporters during system acquisition. In many cases, the same data will meet human factors and Logistics Support Analysis (LSA) requirements. This step can aid in developing human factors constraints and identifying human factors issues to be resolved in the new system, especially costly tasks that degrade total system performance.

CHECKLIST QUESTIONS

- Does the Human Factors Coordinator participate in ILS team meetings?
- Do ILS team members participate in HFWG meetings?
- Has the Human Factors Coordinator reviewed and provided comments on the ILS documentation?
- Have ILS team members reviewed and provided comments on the human factors documentation?
- Has the Human Factors Coordinator participated in ongoing relevant logistical support analyses?
- Have ILS team members participated in ongoing relevant human factors analyses?
- Have HFWG and ILS team members cooperated in developing inputs to the Screening Information Request?
- Have HFWG and ILS team members reviewed contractor proposals to ensure that the Government is only procuring the minimum essential data for each program?
- Have HFWG and ILS team members reviewed the results of human factors and LSA analyses and used them to improve system design, training, staffing, and operational and maintenance concepts?

Appendix A Acronyms

APB	Acquisition Program Baseline
ASP	Acquisition Strategy Paper
CDRL	Contract Data Requirements List
COI	Critical Operational Issues
COTS	Commercial-off-the-Shelf
DID	Data Item Description
DTIC	Defense Technical Information Center
FAA	Federal Aviation Administration
FAST	FAA Acquisition System Toolset
HF	Human Factors
HFC	Human Factors Coordinator
HFDS	Human Factors Design Standard
HFE	Human Factors Engineering
HFWG	Human Factors Working Group
HSIAC	Human-Systems Information Analysis Center
IAR	Investment Analysis Report
IAT	Investment Analysis Team
ILS	Integrated Logistics Support
IPP	Integrated Program Plan
IPT	Integrated Product Team
IRT	Integrated Requirements Team
JRC	Joint Resources Council
LSA	Logistics Support Analysis
MIL-HDBK	Military Handbook

MIL-STD	Military Standard
MNS	Mission Need Statement
MOE	Measure of Effectiveness
MOP	Measure of Performance
NAS	National Airspace System
NDI	Non-developmental Item
NTIS	National Technical Information Service
RD	Requirements Document
SIR	Screening Information Request
SOW	Statement of Work
T&E	Test and Evaluation

Appendix B Glossary

Acquisition Program Baseline
An acquisition document that establishes the performance, cost, schedule, and benefits framework within which an acquisition must be implemented.

Acquisition Strategy Paper
An acquisition document that defines the overall strategy by which an acquisition program will be implemented.

Anthropometry
Of, or relating to, the study of human body measurements, especially on a comparative basis.

Availability
The probability that an item will be operationally ready to perform its function when called upon at any point in time.

Cognition
The act, power, or faculty of apprehending, knowing, or perceiving.

Commercial-off-the-Shelf
A product or service that has been developed for sale, lease, or license to the general public. The product is currently available at a fair market value.

Contract Data Requirements List
A list of data requirements that are authorized for a specific acquisition and made part of the contract.

Critical Operational Issue
A key operational effectiveness or suitability issue that must be examined in operational test and evaluation to determine a system's capability to perform its mission.

Critical Task
A task requiring human performance which, if not accomplished in accordance with system requirements, will most likely have adverse effects on cost, system reliability, efficiency, effectiveness, or safety. A task is also considered critical whenever equipment design characteristics demand human performance which approaches the limits of human capabilities.

Data Item Description
A description of the content and format of the data that is to be provided to the government for a specific acquisition.

Developmental Test and Evaluation
That portion of test and evaluation conducted to assist the engineering design and development process by determining incrementally the degree to which functional engineering specifications are attained.

Evaluation Criteria
Standards used to judge the achievement of operational effectiveness and suitability as they relate to a level of performance against which system characteristics and capabilities are compared (e.g., two false detections per hour).

High Driver Task
A performance task required by the design of the system and which is a significant contributor to the "cost of ownership" of the system by its requirement for high-aptitude users, or substantial training to maintain satisfactory total system performance.

Human Factors
A multidisciplinary effort to generate and compile information about human capabilities and limitations; and apply that information to equipment, systems, facilities, procedures, jobs, environments, training, staffing, and personnel management for safe, comfortable, effective human performance.

Human Factors Engineer
An individual with specialized expertise in human performance as well as in systems engineering and the acquisition process.

Human Factors Engineering
The application of human factors considerations concurrent with other engineering disciplines during the analysis, design, development, testing, and fielding of a system, service, or facility in which human performance is essential in meeting safety and capability objectives.

Human Factors Research
The scientific acquisition of information about human capabilities and limitations related to hardware, software, facilities, procedures, jobs, organizations, environments, training, staffing, errors, situational awareness, workload, personnel management, and other performance implications in which the human is a component in meeting safety and capability objectives.

In-service Management

That part of the lifecycle acquisition management process after commissioning of a product when it is functioning to satisfy mission need.

Integrated Logistics Support
A disciplined, unified, and iterative approach to achieving the integration of support considerations into system and equipment design; the development of support requirements that are related directly to readiness objectives; the acquisition of required support; and the provision of required support during the operational phase at minimum cost.

Integrated Product Team
A multidisciplinary team (with tiered structure) that plans and executes the acquisition of FAA systems to meet mission and customer needs. Included tasks are identification of resource requirements; development of plans, measures, and program milestones; communication with other IPTs; timely execution of plans and activities for lifecycle management; and ensuring the needs and interests of the functional discipline are represented.

Integrated Program Plan
An acquisition document that details the planning for all aspects of program implementation. It integrates the planning requirements of several previous planning documents including the program master plan, the integrated logistics support plan, the test and evaluation master plan, the program implementation plan, the human factors plan, and the procurement plan.

Investment Analysis
That part of the lifecycle acquisition management process that determines the most advantageous solution to an approved mission need. It involves development of operational requirements, a market search to determine industry capabilities, analysis of various alternative approaches for

satisfying requirements, and affordability assessment to determine what the FAA can afford.

Investment Analysis Report
An acquisition document that summarizes the analytical and quantitative information developed during investment analysis in the search for the best means for satisfying mission need.

Maintainability
The ability of an item to be retained in or restored to a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources.

Measures of Effectiveness
Expressions of the system's task accomplishment as they relate to the critical and other operational issues, i.e., how well an item of equipment or system performs in terms of mission completion (e.g., reliability in radar detection).

Measures of Performance
Quantitative or qualitative metrics of the system's capabilities or characteristics as they relate to the measures of effectiveness (e.g., mean false detection rate) or measures of suitability (e.g., consistency of human-system interface).

Measures of Suitability
Expressions of the system's functional and interface design as they relate to the compatibility with other elements of the system, job, organization, other systems, and the working environment (e.g., standardization of CHI).

Mission Analysis
That part of the lifecycle acquisition management process during which the

most critical capability shortfalls and technological opportunities are identified and prioritized. It is a continuous, rigorous, forward-looking analytical activity based on input from the operational workforce, integrated product teams, the aviation community, the NAS architecture, and projections of future demand for services.

Mission Need Statement
An acquisition document that defines a mission shortfall or technological opportunity the FAA should address.

Non-developmental Item
An item that is available in the commercial marketplace including commercial-off-the-shelf equipment; any previously developed item that is in use by a department or agency of the United States, a state or local government, or a foreign government with which the United States has a mutual defense cooperation agreement; or any item that requires only minor modification to meet the requirements of the agency.

Operational Assessment
An evaluation of operational effectiveness and suitability made by an operational test activity, with user support as required, on other than production systems.

Operational Effectiveness
The degree to which a product accomplishes its mission when used by representative personnel in the expected operational environment.

Operational Suitability
The degree to which a product intended for field use satisfies its availability, compatibility, transportability, interoperability, reliability, maintainability, safety, human factors, logistics supportability,

documentation, personnel, and training requirements in the intended environment.

Operational Test and Evaluation
That portion of test and evaluation conducted in an environment as operationally realistic as possible to evaluate the operational effectiveness and suitability of a product including compatibility, interoperability, survivability, maintainability, and supportability.

Performance
Those operational and support characteristics of a product that allow it to perform its mission over time. Support characteristics include support elements necessary for operation.

Personnel
The people needed to develop, operate, maintain, and support a system. Human resource considerations associated with personnel include information relating to their numbers, aptitudes, grades, organizational structure, job category, biographical and training information, anthropomorphic data, and physical qualifications.

Reliability
The ability of a system and its parts to perform its mission without failure, degradation, or demand on the support system.

Requirements Document
An acquisition document that establishes the performance baseline and operational framework for an acquisition program.

Risk
A subjective assessment made regarding the likelihood of achieving an objective within a specified time and with the resources provided.

Risk Management
All actions taken to identify, assess, and eliminate or reduce risk to an acceptable level in selected areas (e.g., cost, schedule, operations, technical, producibility).

Screening Information Request
Any request made by the FAA for documentation, information, or offer for the purpose of screening, and for determining which offeror provides the best value solution for a particular procurement.

Solution Implementation
That part of the lifecycle acquisition management process during which the alternative selected at the investment decision to satisfy mission need is developed to the point where it is ready to go into operational service.

Staffing
The personnel strength as expressed in the numbers, series, and grades of personnel required and/or available. It is expressed in relationship to the applicable organizational level.

Supportability
The degree to which planned support (including test, measurement, and diagnostic equipment; spares and repair parts; technical data; support facilities; transportation requirements; training; manpower; and software support) meets system reliability, availability, and maintainability requirements.

System Safety
The application of engineering and management principles, criteria, and techniques to optimize safety within the constraints of operational

effectiveness, time, and cost throughout all phases of the lifecycle.

Target Population Description
The identification of the salient characteristics of the people who are expected to operate, maintain, and support the system. It is prepared to assist hardware and software designers in considering human aptitudes, performance, capabilities, and limitations.

Task Analysis
The processes by which the human physical and cognitive performance required by a hardware and software configuration is recorded and analyzed. It may include, but not be limited to, task time, task accuracy, knowledge required, skill required, and ability required.

Technical Manual
A publication that contains instructions for installation, operation, maintenance, training, and support for a product, component, or support equipment. A technical manual normally includes operational and maintenance instructions, parts list or parts breakdown, and related technical information or procedures.

Test and Evaluation
Process that verifies how well an acquisition product meets technical and operational requirements; provides data to assess acquisition, developmental, technical, and operational risk for decision making; verifies subsystem performance; and ensures that all critical issues to be evaluated have been adequately considered and resolved.

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Appendix E Human Factors Study Areas

During the conduct of analysis supporting the development of human factors plans, requirements, designs, and other activities, the following solution areas may need to be addressed:

1. **Allocation of Function:** Assigning those roles/functions/tasks for which the human or equipment performs better while enabling the human to maintain awareness of the operational situation.
2. **Anthropometrics and Biomechanics:** Accommodating the physical attributes of its user population (e.g., from the 1st through 99th percentile levels).
3. **CHI (Computer-Human Interaction):** Employing effective and consistent user dialogues, interfaces, and procedures across system functions.
4. **Communications and Teamwork:** Applying system design considerations to enhance required user communications and teamwork.
5. **Displays and Controls:** Designing and arranging displays and controls to be consistent with the operator's and maintainer's tasks and actions.
6. **Documentation:** Preparing user documentation and technical manuals in a suitable format of information presentation, at the appropriate reading level, and with the required degree of technical sophistication and clarity.

7. **Environment:** Accommodating environmental factors (including extremes) to which the system will be subjected and understanding the associated effects on human-system performance.
8. **Functional Design:** Applying human-centered design for usability and compatibility with operational and maintenance concepts.
9. **Human Error:** Examining design and contextual conditions (including supervisory and organizational influences) as causal factors contributing to human error, and consideration of objectives for error tolerance, error prevention, and error correction/recovery.
10. **Information Presentation:** Enhancing operator and maintainer performance through the use of effective and consistent labels, symbols, colors, terms, acronyms, abbreviations, formats, and data fields.
11. **Information Requirements:** Ensuring the availability and usability of information needed by the operator and maintainer for a specific task when it is needed, and in a form that is directly usable.
12. **I/O Devices:** Selecting input and output (I/O) methods and devices that allow operators or maintainers to perform tasks, especially critical tasks, quickly and accurately.
13. **KSAs:** Measuring the knowledge, skills, and abilities (KSAs) required to perform job-related tasks, and determining appropriate selection requirements for users.
14. **Operational Suitability:** Ensuring that the system appropriately supports the user in performing intended functions while maintaining interoperability and consistency with other system elements or support systems.
15. **Procedures:** Designing operation and maintenance procedures for simplicity, consistency, and ease of use.
16. **Safety and Health:** Preventing/reducing operator and maintainer exposure to safety and health hazards.
17. **Situational Awareness:** Enabling operators or maintainers to perceive and understand elements of the current situation, and project them to future operational situations.

18. **Special Skills and Tools:** Minimizing the need for special or unique operator or maintainer skills, abilities, tools, or characteristics.
19. **Staffing:** Accommodating constraints and efficiencies for staffing levels and organizational structures.
20. **Training:** Applying methods to enhance operator or maintainer acquisition of the knowledge and skills needed to interface with the system, and designing that system so that these skills are easily learned and retained.
21. **Visual/Auditory Alerts:** Designing visual and auditory alerts (including error messages) to invoke the necessary operator and maintainer response.
22. **Workload:** Assessing the net demands or impacts upon the physical, cognitive, and decision-making resources of an operator or maintainer using objective and subjective performance measures.
23. **Work Space:** Designing adequate work space for personnel and their tools or equipment, and providing sufficient space for the movements and actions that personnel perform during operational and maintenance tasks under normal, adverse, and emergency conditions.
24. **Culture:** Addressing the organizational and sociological environment into which any change, including new technologies and procedures, will be introduced.

HUMAN FACTORS IN THE FAA ACQUISITION MANAGEMENT SYSTEM PROCESS

(COTS, NDI & Developmental Systems, Services, and Facilities)

PHASE / ACTION	MISSION ANALYSIS	INVESTMENT ANALYSIS	SOLUTION IMPLEMENTATION	IN-SERVICE MANAGEMENT (INCLUDING SERVICE LIFE EXTENSION)
MANAGE THE HUMAN FACTORS PROGRAM	• Identify Human Performance Deficiencies (Ch. 2) • Identify Opportunities to Improve Human Performance (Ch. 2) • Initiate Human Factors Goals and Objectives (Ch. 2)	• Designate Human Factors Coordinator (Ch. 3) • Establish Human Factors Working Group (Ch. 3) • Develop the Human Factors Program (Ch. 3) • Draft Input to the IPP (Ch. 2 and 3)	• Refine the Human Factors Program (Ch. 3) • Prepare Human Factors Input to the IPP (Ch. 2 and 3)	• Refine the Human Factors Program (Ch. 3) • Revise the Human Factors Portion of IPP (Ch. 2 and 3)
ESTABLISH HUMAN FACTORS REQUIREMENTS	• Identify Human Factors Shortfalls and Human Resource Constraints (Ch. 2 and 4)	• Conduct Human Factors Assessment and Establish Human Factors Requirements in Acquisition Documents (Ch. 2, 4, and 5) • Formulate Draft Human Factors Requirements for a System Specification (Ch. 6) • Generate Initial Human Factors Input to the SOW (Ch. 7)	• Revise Human Factors Requirements in the System Specification (Ch. 6) • Refine Human Factors Input to the SOW (Ch. 7) • Specify Human Factors Requirements for Source Selection (Ch. 8)	• Update Human Factors Requirements for System Modifications and Upgrades (Ch. 2, 4, 6, and 7)
CONDUCT HUMAN FACTORS SYSTEM INTEGRATION	• Identify Potential Human Factors Analyses and Trade-offs (Ch. 9)	• Provide Human Factors Inputs to Acquisition Documents (Ch. 2) • Initiate Human Factors Tasks and Activities (Ch. 5 and 9) • Coordinate Human Factors Tasks and Activities with ILS (Ch. 11)	• Revise Human Factors Inputs to Acquisition Documents (Ch. 2) • Continue Human Factors Tasks and Activities (Ch. 9) • Coordinate Results of Human Factors and ILS Analyses (Ch.11)	• Monitor Results of Human Factors and ILS Activities (Ch. 9 and 11)
CONDUCT HUMAN FACTORS TEST AND EVALUATION	• Conduct Preliminary Concept Assessments, Validations, or Demonstrations (Ch. 4 and 10)	• Draft Human Factors Inputs for T&E Plans (Ch. 10) • Conduct Front-end Studies and Analysis (Ch. 4, 5, and 10)	• Revise Human Factors Inputs to T&E Plans (Ch. 10) • Participate in Developmental and Operational Testing (Ch. 10)	• Monitor Human Factors Test and Evaluation Activities (Ch. 10) • Conduct Post-Deployment Assessments (Ch. 10)